NAVIGANT

# 2019 Energy Efficiency Potential and Goals Study

## Final Public Report

**Prepared for:**

**California Public Utilities Commission**


***Submitted by:***

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# EXECUTIVE SUMMARY

Navigant and its partners, Tierra Resource Consultants LLC, Jai J Mitchell Analytics, Cadmus, Opinion Dynamics, and Lumina Decision Systems (collectively known as the Navigant team), prepared this study (2019 Potential and Goals Study or 2019 Study) for the California Public Utilities Commission (CPUC). The purpose of this study is to develop estimates of energy and demand savings potential in the service territories of California's major investor-owned utilities (IOUs) during the post-2019 energy efficiency (EE) rolling portfolio planning cycle. This report includes results for Pacific Gas and Electric (PG&E), Southern California Edison (SCE), San Diego Gas and Electric (SDG&E), and Southern California Gas (SCG). A key component of the 2019 Study is a modeling platform that estimates various levels of EE potential and enables a variety of what-if scenarios. These what-if scenarios represent alternative futures that reflect the complex interactions between numerous data inputs and policy drivers.

## Background and Approach

This study is primarily an update to the most recent potential and goals study completed in 2017 (2017 Study[1]). That study informed the goal-making process for the 2018 and beyond rolling portfolio cycle. During the 2 years since the 2017 Study was completed, several market and policy changes have taken place. These changes are reflected in the 2019 Study. The project kicked off in December 2018 and was followed by a series of stakeholder workshops held January through March 2019 that helped to shape and guide the direction of the results presented in this report.

### *Study Objectives*

The 2019 Study supports several objectives:

- Inform the CPUC as it proceeds to adopt EE savings goals and targets, providing guidance for the next IOU EE program portfolios
- Guide the IOUs in EE program portfolio planning and the state's principal energy agencies in forecasting for procurement, including the planning efforts of the CPUC, California Energy Commission (CEC), and California Independent System Operator (CAISO)
- Inform strategic contributions to SB350 targets
    - The CEC has historically used the potential study to develop its forecast of additional achievable energy efficiency potential (AAEE); SB350 requires doubling AAEE by 2030
    - The CEC will continue to rely on the potential study as an input to AAEE; the potential study will also serve as an input to SB350 target setting
- Identifies new EE savings opportunities

The 2019 Study forecast period spans from 2020 to 2030 based on the direction provided by the CPUC and focuses on current and potential drivers of energy savings in IOU service areas. Analysis of EE savings in publicly owned utility service territories is not part of the scope of this effort.

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[1] Navigant, *Energy Efficiency Potential and Goals Study for 2018 and Beyond*, September 2017.

Consistent with previous CPUC potential studies and common industry practice, the 2019 Study forecasts EE potential at three levels for rebate programs:

- **Technical potential:** Technical potential is defined as the amount of energy savings that would be possible if the highest level of efficiency for all technically applicable opportunities to improve EE were taken regardless of cost.
- **Economic potential:** Economic potential represents total EE potential available when limited to only cost-effective measures.[2] All components of economic potential are a subset of technical potential.
- **Market potential:** The final output of the potential study is a market potential analysis, which calculates the potential EE savings based on specific incentive levels and assumptions about existing CPUC policies, market influences, and barriers. All components of market potential are a subset of economic potential. Market potential has historically been used by the CPUC to inform the goal setting process.

This 2019 Study forecasts the potential energy savings from various EE programs as well as codes and standards (C&S) advocacy efforts for the following customer sectors: residential, low income, commercial, agricultural, industrial, mining, and street lighting. The 2019 Study does not set IOU goals, nor does it make any recommendations as to how to set goals. Rather, it informs the CPUC's goal setting process.

### *Scenarios*

The 2019 Study considers multiple scenarios to explore how EE potential might change based on a number of alternative assumptions about policies, measures, and market response. This study considers scenarios primarily built around policies and program decisions that are within the sphere of influence of the CPUC and its stakeholders collectively. Table ES-1 summarizes the various scenarios considered for the 2019 Study.

[2] The model default is to use the total resource cost (TRC) test as defined by the California Standard Practice Manual. The TRC threshold for what constitutes a cost-effective measure varies by scenario.

**Table ES-1. Scenarios for EE Market Potential**

| Lever | Reference | Alternative 1 | Alternative 2 | Alternative 3 | Alternative 4 |
|---|---|---|---|---|---|
| **Cost-Effectiveness (C-E) Test** | TRC | TRC | TRC | TRC | TRC |
| **C-E Measure Screening Threshold** | 1.0 for all measures | 0.85 for all measures | 1.25 for all measures | 1.0 for all measures | 0.85 for all measures |
| **Incentive Levels** | Capped at 50%* | Capped at 50%* | Capped at 50%* | Capped at 50%* | Capped at 75%** |
| **Marketing and Outreach** | Default calibrated value | Default calibrated value | Default calibrated value | Increased marketing strength | Increased marketing strength |
| **Behavior, Retrocommissioning, and Operational (BRO)s Program Assumptions** | Reference | Reference | Reference | Aggressive | Aggressive |
| **Financing Programs** | No modeled impacts | No modeled impacts | No modeled impacts | No modeled impacts | IOU financing programs broadly available to res and com customers |

*Incentives are set based on a $/kWh and $/therm basis consistent with existing IOU programs; incentives are capped at 50% of incremental cost.
**Incentives are assumed to be 1.5 times higher than what current IOU programs are offering on a $/kWh and $/therm basis, capped at 75% of incremental cost.

### *Changes from Previous Study*

While the 2019 Study framework mirrors past PG studies, several changes were implemented for this study that result in substantially different results than observed from these previous efforts. Table ES-2. highlights the key changes implemented for the 2019 Study with an indication as to what directional impact each change had on the overall results.

**Table ES-2. Key Changes Relative to 2017 Study**

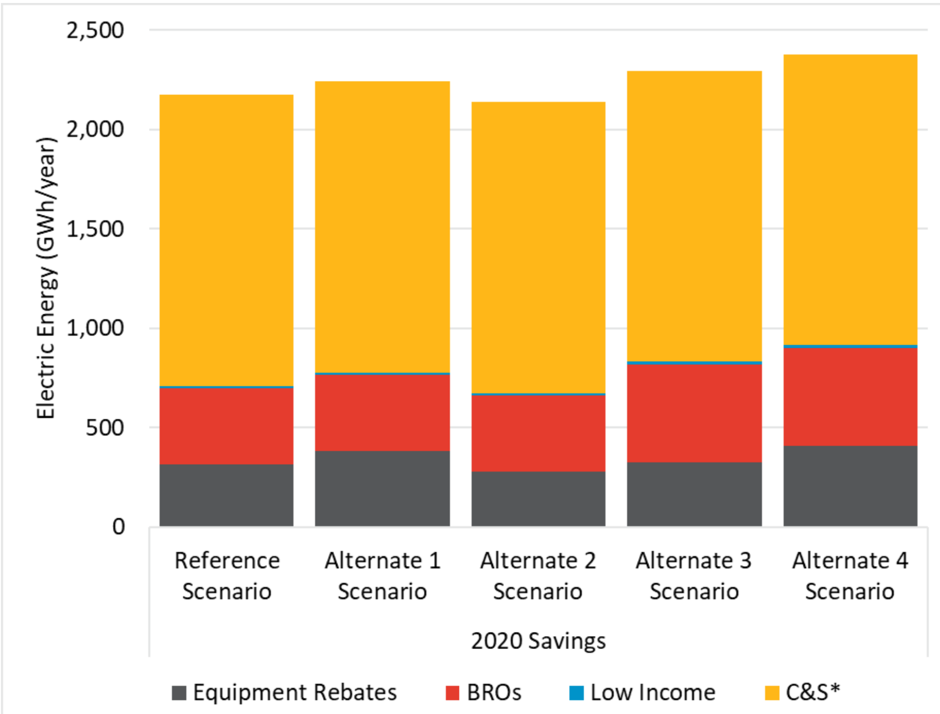
| Category | Update Relative to Previous Study | Directional Impact | |
|---|---|---|---|
| **Baseline Policy** | Recent Database for Energy Efficient Resources (DEER) Resolution E-4952 deemed non-residential lighting standard practice baseline to be LED. Similarly, CPUC staff directed the PG team to assume LEDs are baseline in the residential sector as well. | ↓ | Significantly cuts savings by approximately 225 GWh across all IOUs relative to the previous PG study. |
| **BROs Measures** | Updated data and one measure added relative to 2017 Study (online audits). | ↑ | Increase savings specifically from home energy reports (HERs), and strategic energy management (SEM). |
| **DEER/ Workpapers** | DEER 2020 was used (previously DEER 2017). | ↓ | Majority of weather-sensitive measures were updated, decreasing savings and thus decreasing potential. |
| **Custom Programs** | Using 2 more years of program data that was not previously available (2015-2017). | ↓ | Custom programs show a downward trend over time; previously, the Navigant team saw a flat trend. Potential is decreasing over time. |
| **Low Income Programs** | Recently published evaluations for the Energy Savings Assistance (ESA) Program were leveraged to update model inputs. | ↓ | Evaluation of ESA shows actual program savings are far less than claimed savings. Incorporating this information reduced low income program potential. |
| **Cost-Effectiveness** | 2019 avoided costs being used with approved greenhouse gas (GHG) adder. | ↓ | Slight decrease in avoided costs due to updates to GHG adder, decreases C-E results in the 2020-2030 range. |
| **Cost-Effectiveness** | TRC threshold varies by scenario whereas previous study did not. | ↓ | Scenarios offer more stringent interpretations of C-E threshold than the previous study. |
| **Rebate Program Measures** | New measures relative to 2017 Study: smart connected power strips and connected LEDs. | ↑ | Increase residential savings potential but not enough to backfill loss of LED savings. |

## Results

### *Total Electric Market Potential*

Figure ES-1 shows the total 2020 (first year) electric market potential for each type of EE program delivery approach.[3] The figure illustrates the magnitude of market potential for each EE program type for each of the five scenarios listed in Table ES-1.

**Figure ES-1. 2020 Net Statewide Incremental Electric Savings by Scenario**




*Includes interactive effects

Some notable takeaways from the electric results include the following:

- The overall electric savings are approximately 6% lower than the total savings observed from the previous PG study. While the total is relatively comparable, there is a significant shift in savings from equipment rebate programs to BROs programs and C&S.
- Savings from equipment rebate programs dropped about 45% relative to the previous PG study. This drop is primarily driven by the loss of nearly 225 GWh of lighting savings due to CPUC baseline policy changes.
- It is important to note that while a significant amount of lighting savings is no longer represented in the rebate program potential estimates, they are not lost. Rather, lighting savings are captured through codes and standards and through naturally occurring EE (the latter of which was not quantified as part of this study or claimable by IOU programs.)

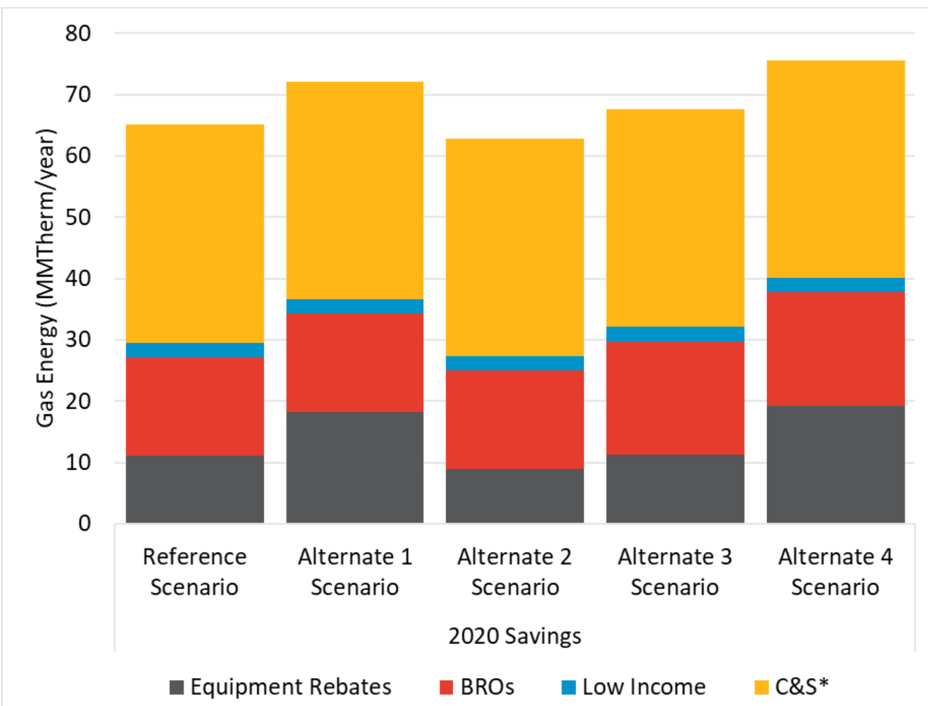
[3] Note that this study categorizes the following EE program areas: equipment rebates; behavior, retrocommissioning, and operational efficiency (BROs); low income; and codes and standards (C&S).

- Savings from BROs programs increased approximately 30% in 2020 relative to the previous PG study. This increase is mainly driven by revised data on HERs and the addition of online audits.
- Consistent with past PG studies, the largest contributor to savings comes from C&S programs. It should be noted that C&S advocacy efforts have historically been provided as a separate goal from incentive programs.
- The Alternative 4 scenario appears to yield the highest electric savings potential. This scenario assumes the most permissive C-E threshold at 0.85 for all measures and highly ambitious efforts aimed at increasing customer uptake of various EE programs. These efforts include high rebate amounts, stepped-up marketing and outreach efforts, aggressive BROs interventions, and innovative financing approaches targeted to the residential and commercials sectors.

### *Total Gas Market Potential*

Figure ES-2 shows the total 2020 (first year) gas market potential for each type of EE program delivery approach. The figure illustrates the magnitude of market potential for each EE program type for each of the five scenarios listed in Table ES-1.

**Figure ES-2. 2020 Net Statewide Incremental Gas Savings by Scenario**




*Includes interactive effects

Some notable takeaways from the gas results include the following:

- The overall gas savings are substantially lower than the total savings observed from the previous PG study. Reductions are seen in virtually every program category, except BROs.
- Savings from equipment rebate programs dropped more than 20% relative to the previous PG study. The reductions for equipment rebate programs are primarily driven by updated data on IOU-claimable savings.

- Savings from BROs programs increased approximately 12% in 2020 relative to the previous PG study. This increase is mainly driven by revised data on SEM programs.
- Consistent with past PG studies, the largest contributor to savings comes from C&S programs. It should be noted that C&S advocacy efforts have historically been provided as a separate goal from incentive programs.
- The Alternate 4 scenario appears to yield the highest gas savings potential. This scenario assumes the most permissive C-E threshold at 0.85 for all measures and highly ambitious efforts aimed at increasing customer uptake of various EE programs. These efforts include high rebate amounts, stepped-up marketing and outreach efforts, aggressive BROs interventions, and innovative financing approaches targeted to the residential and commercials sectors.

# 1. INTRODUCTION

## 1.1 Context of the Goals and Potential Study

Navigant and its partners, Tierra Resource Consultants LLC, Cadmus, Opinion Dynamics, Jai J Mitchell Analytics, and Lumina Decision Systems (collectively known as the Navigant team), prepared this study (2019 Potential and Goals Study or 2019 Study) for the California Public Utilities Commission (CPUC). The purpose of this study is to develop estimates of energy and demand savings potential in the service territories of California's major investor-owned utilities (IOUs) during the post-2019 energy efficiency (EE) rolling portfolio planning cycle. This report includes results for Pacific Gas and Electric (PG&E), Southern California Edison (SCE), San Diego Gas and Electric (SDG&E), and Southern California Gas (SCG). A key component of the 2019 Study is the Potential and Goals Model (PG Model), which provides a single platform in which to conduct robust quantitative scenario analysis that reflects the complex interactions among various inputs and policy drivers.

The 2019 Study is the fifth consecutive potential study conducted by the Navigant team on behalf of the CPUC. The last study published was the 2017 Study, which informed goals for 2018 and beyond.[4]

The 2019 Study is primarily an update of the 2017 Study. The project kicked off in December 2018 and followed with a presentation of the draft workplan to stakeholders on January 11, 2019. This is a significantly compressed timeline relative to past CPUC Potential and Goals (PG) studies; as such, the opportunities to update methodologies, add measures, and deeply engage stakeholders was limited. This is not to say no progress was made on these fronts, but rather a truncated effort was needed given the timeline.

The 2019 Study supports multiple related efforts:

- Inform the CPUC as it proceeds to adopt goals and targets, providing guidance for the next IOU EE portfolios. The potential model is a framework that facilitates the stakeholder process. The model helps build consensus for goals by soliciting agreement on inputs, methods, and model results.
- Inform strategic contributions to SB350 targets. The California Energy Commission (CEC) has historically used the PG study to develop its forecast of additional achievable energy efficiency potential (AAEE). SB350 targets a doubling of the AAEE by 2030. The CEC will continue to rely on the PG study as an input to AAEE; the PG study will also serve as an input to SB350 target setting.
- Inform Integrated Resource Planning (IRP). In late 2017 and early 2018, Navigant supported CPUC staff in examining methods to integrate EE procurement practices into the IRP optimization process. Those efforts leveraged outputs from the 2017 Study to develop input to the IRP model. The results of this study will continue to inform future IRP modeling efforts under subsequent analysis not contained in this report.
- Guide the IOUs in portfolio planning and the state's principal energy agencies in forecasting for procurement, including the planning efforts of the CPUC, CEC, and California Independent System Operator (CAISO). Although the model cannot be the sole source of data for IOU

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[4] Navigant, *Energy Efficiency Potential and Goals Study for 2018 and Beyond*, September 2017.

program planning activities, it can provide critical guidance for the IOUs as they develop their plans for the 2020 and beyond portfolio planning period. The study is also providing California's principal energy agencies with the tools and resources necessary to develop outputs in a manner that is most appropriate for their planning and procurement needs.

The study period spans from 2020 to 2030 based on the direction provided by the CPUC and focuses on current and potential drivers of energy savings in IOU service areas. Analysis of EE savings in publicly owned utility service territories is not part of the scope of this effort.

## 1.2 Types of Potential

Consistent with the 2017 Study and common industry practice, the 2019 Study forecasts EE potential at four levels for rebate programs:

- **Technical potential:** Technical potential is defined as the amount of energy savings that would be possible if the highest level of efficiency for all technically applicable opportunities to improve EE were taken, including retrofit, replace on burnout, and new construction measures. Technical potential in existing buildings represents the immediate replacement of applicable equipment-based technologies regardless of the remaining useful life of the existing measure. Technical potential in new construction buildings represents installation of highest level of efficiency at the time of construction. Technical potential is undefined for codes and standards (C&S), whole building, and behavior, retrocommissioning, and operational efficiency (BROs) programs.
- **Economic potential:** Using the results of the technical potential analysis, the economic potential is calculated as the total EE potential available when limited to only cost-effective measures.[5] All components of economic potential are a subset of technical potential. Economic potential may be a fraction of technical potential as the economic screen is applied separately to new construction vs. existing buildings.
- **Market potential:** The final output of the potential study is a market potential analysis, which calculates the EE savings that could be expected in response to specific levels of incentives and assumptions about existing CPUC policies, market influences, and barriers. Some studies also refer to this as achievable potential. Market potential is used to inform the utilities' EE goals, as determined by the CPUC. Market potential has historically been used by the CPUC to inform the goal setting process. Market potential is primarily reported as a net savings value (CPUC shifted to setting goals based on net savings in 2017), though gross values are also produced by the model.
- **Below code potential** is a subset of the market potential. These savings are defined as the opportunities for EE that program administrators can claim through accelerated replacement programs. These savings reflect additional claimable impacts allowed after the passing of AB802.

Market potential is represented in the 2019 Study two different ways; each is based on the same data and assumptions, though each serve separate needs and provide necessary perspectives.

- **Incremental savings** represent the annual energy and demand savings achieved by the set of programs and measures in the first year that the measure is implemented. It does not consider

[5] The model default is to use the total resource cost (TRC) test as defined by the California Standard Practice Manual. The TRC threshold for what constitutes a cost-effective measure varies by scenario.

the additional savings that the measure will produce over the life of the equipment. A view of incremental savings is necessary to understand what additional savings an individual year of EE programs will produce. This has historically been the basis for IOU program goals.

- **Cumulative savings** represent the total savings from EE program efforts from measures installed since 2020 (including the current program year) and that are still active in the current year. It includes the decay of savings as measures reach the end of their useful lives and the continuation of savings as customer re-install high efficiency equipment that has reached the end of its effective useful life (EUL). Cumulative savings also account for the timing effects C&S that become effective after measure installation.

Many variables drive the calculation of market potential. These include assumptions about the way efficient products and services are marketed and delivered, the level of customer awareness of EE, and customer willingness to install efficient equipment or operate equipment in ways that are more efficient. The Navigant team used the best available current market knowledge to calibrate market potential for voluntary rebate programs.

## 1.3 Scope of this Study

This study forecasts the potential energy savings from the EE programs and C&S across all customer sectors: residential, low income, commercial, agricultural, industrial, mining, and street lighting. This study does not set IOU goals, nor does it make a recommendation as to how to set goals. Rather, it informs the CPUC's goal setting process.

The study builds upon the 2017 Study; notable updates to the 2019 Study relative to the 2017 Study include the following:

- **Refresh measure inputs:** The 2019 Study conducted a prioritized refresh of measure input data. The study continued to use the same measure list as the 2017 Study, making a few additions where warranted. The 2017 Study conducted a comprehensive process involving stakeholders to develop the measure list for both equipment rebate programs and BROs. During this data refresh, the Navigant team reflected the new definition of peak demand savings as codified in the Database for Energy Efficient Resources (DEER), vintage 2020.
- **Improve low income sector methodology:** The 2019 Study conducts a bottom-up forecast of savings from the residential low income sector. This is a major departure from the 2017 Study in which a top-down analysis was conducted. The new bottom-up analysis uses data for individual measures and incorporates low income market characterization data.
- **Revise scenarios to inform goal setting:** The 2019 Study solicited informal feedback from stakeholders on scenarios to consider. The 2017 Study also included scenarios but did not seek significant stakeholder feedback in the process selecting the final scenarios to run.

The initial workplan for this study included considering multiple additional topics. These topics explore further policy questions or provide more granularity of results. However, their outcome does not inform the goal setting process. Due to the short timeline to conduct the 2019 Study and the need for more input from stakeholders and CPUC staff, the following topics will be discussed and explored in a second volume to be published later in 2019.

- **Fuel Substitution:** The Navigant team did not examine fuel substitution but will conduct research to set a foundation to integrate fuel substitution into a future potential study cycle. This research will identify candidate measures, identify available data and data gaps, and document a framework for modeling.

- **EE/demand response (DR) co-modeling:** The model used in the 2019 Study is not set up to forecast both EE and DR potential. The Navigant team will conduct research to set a foundation for how EE/DR co-modeling could be integrated into a future potential study cycle. The team expects to coordinate with other DR potential modeling efforts funded by the CPUC in the foundational research step.
- **Savings within disadvantaged communities (DACs):** The Navigant team proposed a high level approach to parsing out savings in DACs to stakeholders in January 2019; little feedback was provided. The team expects this analysis to be largely a post-processing step that will aim to size the market potential attributable to DACs. Since program goals are set on an aggregate basis and are not specific to DACs, this research will be conducted later in 2019.
- **Savings within RENs/CCAs:** The Navigant team proposed a high level approach to parsing out savings in Regional Energy Networks (RENs) and Community Choice Aggregators (CCAs) to stakeholders in January 2019. The team expects this analysis to be largely a post-processing step that will aim to size the market potential attributable to RENs and CCAs. However, uncertainty around the planned growth of RENs and CCAs as well as the expected use of these results requires additional discussion with CPUC staff and input from stakeholders. Since program goals are set on an aggregate basis and are not specific to RENs or CCAs, this research will be conducted later in 2019.

## 1.4 Changes Since the Previous Study

Several impactful market and policy updates have occurred in the last 2 years, driving key changes to the results of the PG study. They are described in Table 1-1..

**Table 1-1. Changes and Impacts Relative to 2017 Study**

| Category | Change | Impact on Study |
|---|---|---|
| **Baseline Policy** | Recent DEER Resolution E-4952 deemed non-residential lighting standard practice baseline to be LED. Similarly, CPUC staff directed the PG team to assume LEDs are baseline in the residential sector as well. | Significantly cuts lighting savings across all sectors, which were a large part of past IOU programs and goals. The amount of savings reduced is approximately 225 GWh across all IOUs when comparing the year 2020 to the previous PG study results.<br>These savings are above code and, may not fully appear in forecasted IOU C&S claims. Savings lost from IOU programs because of this policy may move to a category of naturally occurring savings not forecast by this study (or claimable by IOU programs). |
| **BROs Measures** | Updated impact evaluation data was used and new measures added relative to the previous PG study (online audits). | Increase incremental first-year savings from BROs, specifically from home energy reports (HERs), online audits, and strategic energy management (SEM) |

| Category | Change | Impact on Study |
|---|---|---|
| **DEER/ Workpapers** | DEER 2020 is a primary source of measure input data (the previous study relied on DEER 2017). | Majority of weather-sensitive measures were updated, decreasing savings and thus decreasing potential specifically impacting residential gas savings. DEER 2020 also implements the new definition of peak demand savings. |
| **Custom Project Savings** | This study used more recent years of program data not previously available; this recent data shows a downward trend in savings. | Industrial and agriculture custom project savings are projected to decrease in the forecast range. |
| **Low Income Programs** | Recently published evaluations for the Energy Savings Assistance (ESA) Program were leveraged to update model inputs. | Evaluation of ESA shows program realization rates in the range of 18 - 53% in 2017 across the IOUs. Some measures were found to save no energy in ESA programs. Implementing this data reduced low income program potential. |
| **Cost-Effectiveness** | This study uses avoided costs published in 2018 after the CPUC-approved greenhouse gas (GHG) adder went into effect. The previous study used a higher estimate of the GHG adder. | Slight decrease in avoided costs due to updates to the GHG adder, which decreases cost-effective market potential results in the 2020-2030 range. |
| **Rebate Program Measures** | New measures were added to this study relative to the 2017 Study: smart connected power strips and connected LEDs. | Increase in residential savings potential but not enough to backfill the loss of claimable LED savings. |

## 1.5 Stakeholder Engagement

The Navigant team engaged with stakeholders through multiple public workshops, in part supported by the Demand Analysis Working Group.[6] These workshops were used to request data, collect feedback on scope, discuss methodology, and discuss key assumptions. Table 1-2. provides the schedule of meetings that were held. After each meeting, stakeholders were provided a period in which they could submit informal comments to the Navigant team and CPUC. The team reviewed all comments received and incorporated appropriate edits/changes into the study.

**Table 1-2. Stakeholder Meeting Schedule**

| Date | Topics of Discussion |
|---|---|
| January 11, 2019 | Overview of the scope of the 2019 Study |
| February 4, 2019 | (Webinar) AIMS Emerging Tech and Generic Custom Methodology |

[6] http://demandanalysisworkinggroup.org/

| | |
|---|---|
| February 21, 2019 | (Webinar) Scenarios |
| March 21, 2019 | Calibration Workshop |
| May 9, 2019 | Presentation of Draft Results<br>(formal comments allowed until May 21, 2019 and reply comments allowed until May 31, 2019) |

## 1.6 Content of this Report

This report documents the data relied upon by and the results of the 2019 Study.

- **Section 2** provides an overview of the methodology for each key area of the study.
- **Section 3** provides details on the input data used for each key area of the study. It describes the data sources and process taken to incorporate the data into the PG Model.
- **Section 4** provides the study's results on a statewide basis.
- **Section 5** focuses only on Low Income programs and provides the study's methodology, data assumptions and results on a statewide basis.
- **Appendices** provide additional details for key topic areas.

Aside from this report, the following supporting deliverables are available to the public via the CPUC's website:[7]

- **2019 PG Results Explorer:** A web-based tool that allows readers to dynamically explore the results of the study, including all five scenarios. Available at: https://bit.ly/2019-CA-Energy-Efficiency-PG-Study
- **2019 PG MICS:** A spreadsheet version of the Measure Input Characterization System documenting all final values for all rebated technologies forecast in the model.
- **2019 PG BROs Inputs:** A spreadsheet version of all measure-level inputs for BROs measures.
- **2019 PG Measure Level Results Database:** A spreadsheet of technical, economic, and market potential for each measure in each sector, end use, and utility.
- **2019 PG Model File:** An Analytica-based file that contains the PG Model used to create the results of this study.
- **2019 PG Model Users Guide:** Document that helps advanced users who want to open and run the PG Model file in Analytica.

[7] http://www.cpuc.ca.gov/General.aspx?id=6442452619

# 2. STUDY METHODOLOGY

The primary purpose of the 2019 Study is to provide the CPUC with information and analytical tools to engage in goal setting for the IOU EE portfolios. In addition, this study informs forecasts used for procurement planning. The study itself does not establish any regulatory requirements.

The 2019 Study forecasts potential energy savings from a variety of sources within seven distinct customer sectors: residential, low income, commercial, agricultural, industrial, mining, and street lighting. These sectors are also used in the CEC's Integrated Energy Policy Report (IEPR) forecast. Within some or all the sectors, sources of savings include the following:

- **Rebated technologies:** Discrete mass market technologies that are incentivized and provided to IOU customers in the residential, commercial, industrial, agricultural, mining, and street lighting sectors. These sectors are modeled using individual measures for specific applications.
- **Whole building approaches:** In the case of whole building initiatives, the measure is characterized for the building retrofit or house retrofit rather than for specific technology or end uses. Whole building initiatives are modeled for the residential and commercial sectors.
- **Custom measures and emerging technologies:** This study defines custom measures as improvements to processes specific to the industrial and agricultural sectors; the measures themselves are not individually defined and rather represent a wide array of niche technologies. Similarly, emerging technologies are represented as a wide array of technologies and not individually defined.
- **Behavior, retrocommissioning, and operational efficiency (BROs):** For the purposes of this study, the Navigant team defines behavior-based initiatives as those providing information about energy use and conservation actions rather than financial incentives, equipment, or services. Savings from BROs are modeled as incremental impacts of behavior and operational changes beyond equipment changes.
- **Codes and standards (C&S):** Codes regulate building design, requiring builders to incorporate high efficiency measures. Standards set minimum efficiency levels for newly manufactured appliances. Savings are forecast from C&S that went into effect starting in 2006.
- **Financing:** Financing has the potential to break through several market barriers that have limited the widespread market adoption of cost-effective EE measures. The PG Model estimates the effects of introducing EE financing on market potential and how shifting assumptions about financing affect the potential energy savings.
- **Residential low income:** The 2019 Study conducts a bottom-up forecast of savings from the residential low income sector. This is a major departure from the 2017 Study in which the Navigant team conducted a top-down analysis. The new analysis uses low income-specific market characterization data and applies the same measure list as the residential sector.

The modeling methodology leverages much of what was used in the 2017 Study. The rest of this section discusses the 2019 Study methodology.

## 2.1 Modeling Methods

Table 2-1. summarizes the modeling approach for each source of savings. Each approach is discussed in more detail in the subsequent subsections.

**Table 2-1. Overview of Modeling and Calibration Approach**

| Savings Source | Summary of Modeling Approach | Summary of Calibration Approach | Methodology Change Relative to 2017 Study? |
|---|---|---|---|
| **Rebated technologies** | Bass diffusion forecast competes below code, at code, and above code technologies against each other. | Calibrated to historic program spending. | No |
| **Whole building packages** | Bass diffusion forecast competes below code, at code, and above code technologies against each other. | Calibrated to historic program spending. | No |
| **Industrial/Agriculture custom measures and emerging technologies** | Trend forecast based on recent IOU custom project savings in these sectors. Emerging technologies can ramp up the trend in the future. | Forecast is anchored in IOU program history and thus inherently calibrated to current market conditions. | No |
| **BROs** | Interventions are limited to the applicable customers and markets. For the applicable markets, Navigant assumptions are made regarding reasonable penetration rates. | Starting penetration rates are based on current penetration rates. | No |
| **C&S** | Model replicates the algorithms of the CPUC's Integrated Standards Savings Model (ISSM). | Calibration not needed as evaluated results are used. | No |
| **Financing** | Financing is applied to rebated technologies and whole building approaches. It reduces upfront barriers, increasing consumer adoption, and supplements Bass diffusion modeling framework. | No program data to calibrate to. | No |
| **Residential low income** | Bass diffusion forecast competes below code, at code, and above code technologies against each other. (Discussed in greater detail in Section 5) | Calibrated to historic low income program accomplishments. | Yes |

### *2.1.1 Rebated Technologies*

Rebated technologies make up the majority of historic program spending and savings claims. Thus, they are a core part of the forecast. The Navigant team's approach to modeling rebated technologies has not changed since the 2017 Study. This methodology is documented in this section.

#### 2.1.1.1 Types of Technologies

The PG study forecasts the adoption of more than 150 EE technologies. Each measure can be classified into one of several broad measure types. Each measure type is treated differently in terms of calculating cost-effectiveness, calculating energy savings relative to the baseline, and modeling consumer decisions and market adoption. These differences are further discussed throughout this section of the report. The types of measure installations are outlined below:

- **New Construction:** Equipment installed in a newly constructed building. In this situation, energy savings calculations are always relative to code.
- **Installation in Existing Buildings:**
    - **Equipment**
        - ***Replace on burnout (ROB):*** New equipment needs to be installed to replace equipment that has reached the end of its useful life, has failed, and is no longer functional. Upon failure, ROB equipment is generally not repaired by the customer and is instead replaced with a new piece of equipment. Appliance standards are applicable to some types of ROB equipment and apply to all new purchases.
        - ***Accelerated replacement (AR):*** Equipment that is beyond its EUL and is continuing to function in the market. The customer is not planning to replace the equipment on a regular cycle; thus, programs are targeted at the customer to accelerate the equipment's replacement. Dual baselines are applied to these measures.
    - **Retrofit (RET)**
        - ***RET add-on:*** New equipment being installed onto an existing system, either as an additional, integrated component or to replace a component of the existing system. In either case, the primary purpose of the add-on measure is to improve overall efficiency of the system. These measures are not able to operate on their own as standalone equipment and are not required to operate the existing equipment or building. Codes or standards may be applicable to some types of RET add-on measures by setting minimum efficiency levels of newly installed equipment, but the codes or standards do not require the measure to be installed.
        - ***RET replacement:*** Measures that will be replaced not due to equipment failure but rather triggered by building renovation. These measures are those that are installed to replace previously existing equipment that has either not failed or is past the end of its EUL but is not compromising use of the building (such as insulation and water fixtures). Many of these installations are subject to building code, but upgrades are not always required by code until a major building renovation (and even then, some may not be required).

#### 2.1.1.2 Technology Groups, Efficiency Levels, and Competition

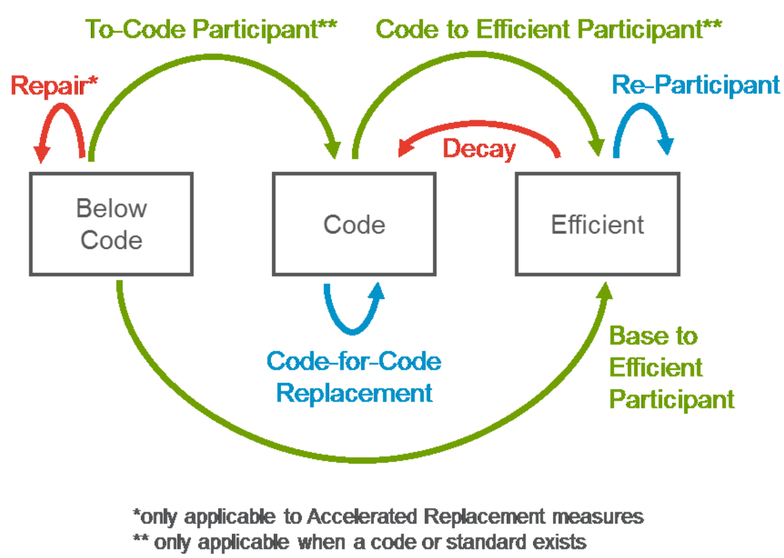
Within each technology type, multiple groups of technologies are formed and characterized. A technology group consists of multiple levels of efficiency of the same technology, an example of which is illustrated in Table 2-2.. Technologies within a technology group compete for installations. The individual technologies characterized within each group are designed to capture varied efficiency levels including below code units, at code units, and multiple levels of high efficiency units (up to and including emerging technologies, where appropriate.) In determining which technologies to include in a group, the Navigant team considered possible future code levels as well as popular efficiency levels historically rebated by IOU programs.

**Table 2-2. Example of Technologies within a Technology Group**

| Technology Group | Technology | Description |
|---|---|---|
| Residential Central AC | Residential Seasonal Energy Efficiency Ratio (SEER) 10 AC | Average Below Code Efficiency Level |
| | Residential SEER 13 AC | Code Efficiency Level Pre-2015 |
| | Residential SEER 14 AC | Code Efficiency Level 2015 and Beyond |
| | Residential SEER 15 AC | High Efficiency Level 1 |
| | Residential SEER 18 AC | High Efficiency Level 2 |
| | Residential SEER 20 AC | High Efficiency Level 3 |

The model simulates the flow of equipment stock across the different technologies within a technology group. Flow of stock occurs when the customer owning the equipment reaches a decision point to either maintain the existing equipment or replace it with a new unit. The decisions available to the customer in the model depend on the type of technology category (discussed in Section 2.1.1.1) the equipment in question falls in. Figure 2-1 illustrates the replacement options a customer is faced with. The model allows customers to maintain their existing equipment, upgrade to higher efficiency equipment, or downgrade from high efficiency equipment to code-level equipment. With each replacement a unit energy savings, cost, and C-E value is associated with the decision.

**Figure 2-1. Stock Flow within a Technology Group**



#### *2.1.1.3 Technical and Economic Potential*

Technical potential is defined as the amount of energy savings that would be possible if the highest level of efficiency for all technically applicable opportunities to improve EE were taken, including RET measures, ROB measures, and new construction measures. As previously discussed, technical potential can be reported in two forms: instantaneous and annualized. The following considerations are factored into the team's calculation of technical potential:

- Technical potential assumes all eligible customers within a technology group adopt the highest level of efficiency available within the technology group.
- Technical potential represents the savings from converting all equipment that is at or below code to the highest level of efficiency within a technology group.
- Total technical potential is the sum of all individual technical potential within each technology group excluding whole building packages, low income programs, and BROs. Whole building packages are excluded from the technical potential as doing so would be duplicative. Technical potential for low income programs and BROs are undefined in this study.

Using the results of the technical potential analysis, the economic potential is calculated as the total EE potential available when limited to only cost-effective measures. All components of economic potential are a subset of technical potential. In addition to the above considerations in modeling technical potential, the following considerations are factored into the team's calculation of economic potential:

- Economic potential assumes all eligible customers within a technology group adopt the highest **cost-effective** level of efficiency available within the technology group. The most efficient technology within the group may not be cost-effective.
- Various C-E screens can be applied (previously discussed in Section 1.2); thus, economic potential can vary by scenario. Meanwhile, technical potential does not vary by scenario.

#### *2.1.1.4 Market Potential*

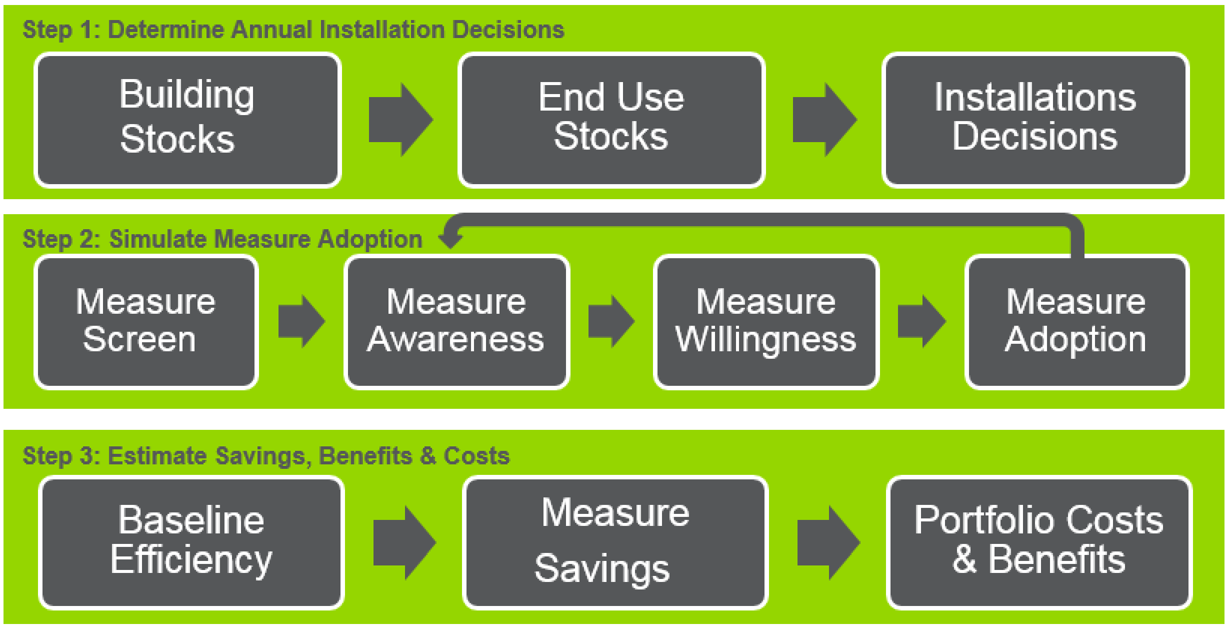
To estimate the market potential for rebated technologies, the model employs a three-step process, as shown in Figure 2-2. In the first step, the model calculates the number of installation decisions expected to occur for each measure in each year. The types of installation decisions vary by type of technology. For ROB technologies (e.g., residential lighting), the customer decision to adopt occurs at the end of the base measure's life. For AR where equipment is past the EUL (e.g., commercial chillers), the Navigant team models the customer decision to adopt past the EUL (based on the extended life due to repair). Finally, for RET technologies, the customer adoption decision is not governed by equipment failure and thus can occur before or after the EUL. The model simulates technology stocks for base and efficient technologies separately to account for EUL differences. The number of adoption decisions that occur in each year is considered the eligible population, which is a function of the building stocks, technology saturation, type of technology, and technology burnout rates (i.e., based on EUL).

In the second step, the model simulates the adoption of each measure that passes a C-E screen in each year. The model considers the number of installation decisions that may occur in each year, the estimated level of awareness of each measure in the eligible population, and the willingness to adopt each measure that passes the C-E screen. It is in this step that the model employs the Bass diffusion approach to simulate adoption (described in more detail below).

In the final step, the model calculates energy savings and corresponding costs and benefits resulting from measure adoption decisions in the second step. Savings are calculated relative to the appropriate baseline efficiency level depending on the type of replacement.

**Figure 2-2. Three-Step Approach to Calculating Market Potential for Rebated Measures**

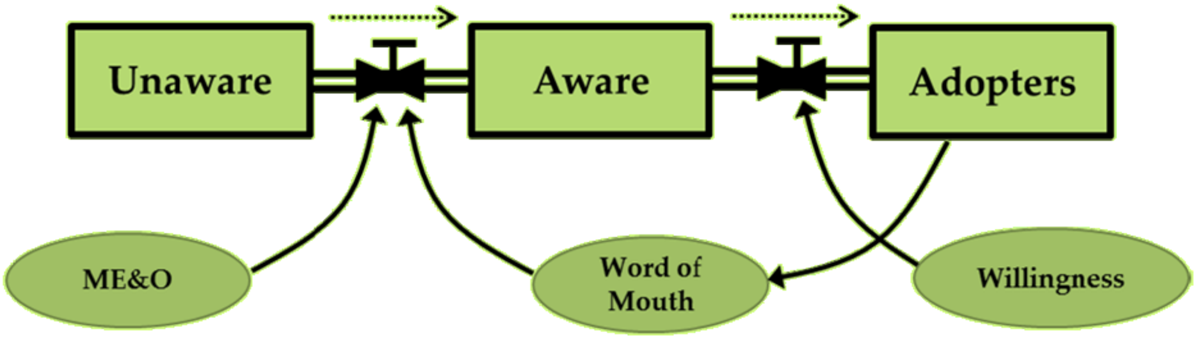



The model employs a bottom-up, dynamic Bass diffusion approach to simulate the market adoption of efficient measures. The Bass diffusion model is illustrated in Figure 2-3 and contains three parameters:

- **Marketing, education, and outreach** (ME&O) moves customers from the unaware group to the aware group at a consistent rate annually. Unaware customers, as the name implies, have no knowledge of the energy efficient technology option. Aware customers are those that have knowledge of the product and understand its attributes. ME&O is often referred to as the Advertising Effect in Bass diffusion modeling.
- **Word of mouth** represents the influence of adopters (or other aware consumers) on the unaware population by informing them of efficient technologies and their attributes. This influence increases the rate at which customers move from the unaware to the aware group; the word of mouth influence occurs in addition to the ongoing ME&O. When a product is new to the market with few installations, often ME&O is the main source driving unaware customers to the aware group. As more customers become aware and adopt, however, word of mouth can have a greater influence on awareness than ME&O and lead to exponential growth. The exponential growth is ultimately damped by the saturation of the market, leading to an S-shaped adoption curve, which has frequently been observed for efficient technologies.
- **Willingness** is the key factor affecting the move from an aware customer to an adopter. Once customers are aware of the measure, they consider adopting the technology based on the financial attractiveness of the measure. The PG Model applies two distinct approaches to calculate willingness depending on the sector and need. Additional discussion of willingness follows Figure 2-3.

**Figure 2-3. The Bass Diffusion Framework:**
**A Dynamic Approach to Calculating Measure Adoption**[8]




### Approach to Calculating Willingness

Customer willingness to adopt is a key determinant of long-run market share—i.e., what percentage of individuals choose to purchase a technology provided those individuals are aware of the technology and its relative merits (e.g., the energy- and cost-saving features of the technology). The PG Model applies two approaches to calculating willingness depending on the sector:

- **Levelized measure cost/logit approach:** For the residential and commercial sectors where information on baseline and efficient costs are available and to more appropriately capture the impacts of EE financing on market adoption, a levelized measure cost (LMC)/logit approach is applied. The LMC is based on the present value of the cost of purchasing and operating the equipment throughout its EUL, discounted using a consumer implied discount rate (iDR).[9] The equation used to calculate the LMC is shown below.

  **Equation 2-1. Levelized Measure Cost Calculation**

  $$LMC = Upfront\ Cost + PV(Annual\ Operating\ Cost,\ iDR,\ EUL)$$

  To calculate long-run market share or willingness as a function of the LMC for both base and efficient technologies, the Navigant team employed a logit decision maker approach.[10, 11] This approach applies best practices in predicting consumer behavior and allows competition of multiple measures with different EULs for each end use.

  **Equation 2-2. Logit Decision Model**[12]

  $$W = \frac{e^{\,\beta\ LMC1}}{\sum_i^n e^{\,\beta\ LMCi}}$$

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[8] Adapted from John Sterman. 2000. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. McGraw-Hill.

[9] See 2015 Study for details on the iDR

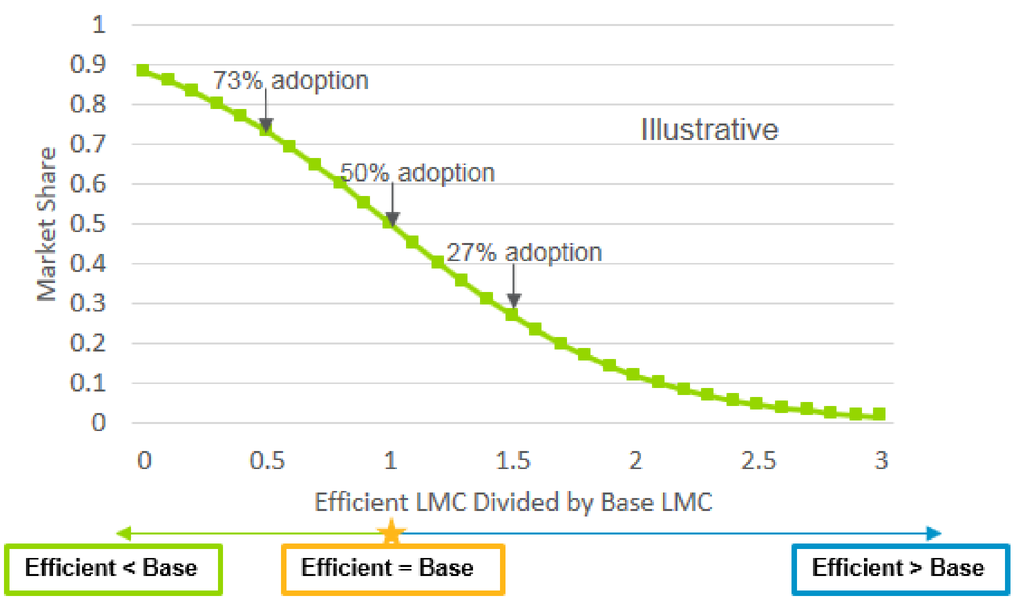
[10] *McFadden, Daniel, Train, K. "Mixed MNL Models for Discrete Response." 2000. Journal of Applied Econometrics, Vol. 15, No. 5, pp. 447-470.*

[11] *Train, Ken. "Discrete Choice Methods with Simulation." 2003. Cambridge University Press.*

[12] In this equation, W is the willingness, $\beta$ is a sensitivity factor fit to willingness survey results, n is the number of competing technologies, and LMC is the levelized measure cost.

Figure 2-4 illustrates how consumer willingness changes as a function of the ratio of the efficient to base LMC. In this illustration, an LMC ratio of 1 implies both the efficient and base technologies are at parity and thus the market is split, with 50% choosing to adopt the efficient technology. For an LMC ratio of 0.5, which implies the efficient technology is cheaper than the base technology, the curve indicates that 73% would adopt the efficient technology.

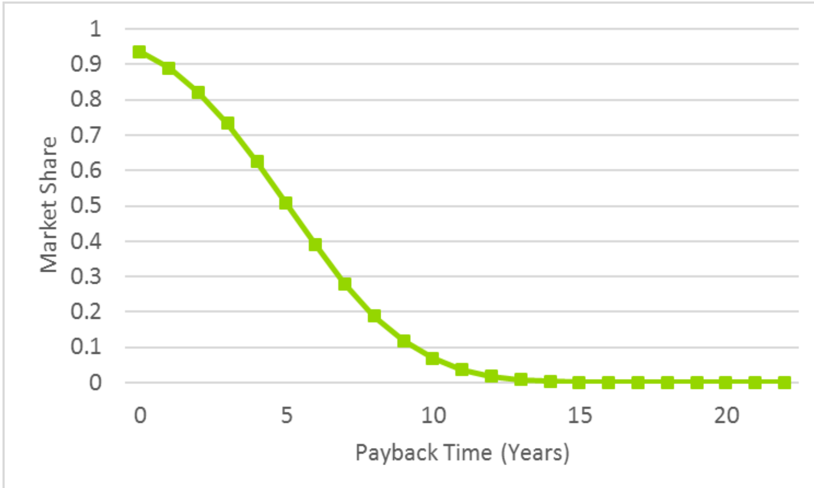
**Figure 2-4. Illustration of Logit Willingness Curve**




- **Payback-based approach:** For the agriculture, industrial, mining, and street lighting (AIMS) sectors where information on baseline technology costs is not available and where there is no need to explore the impacts of EE financing, the Navigant team used a payback-based approach to calculate willingness. Payback time reflects the length of time (years) required for an EE investment to recover the initial upfront cost in terms of energy savings. After calculating payback time, to estimate market share for the AIMS measures, the team relied on payback acceptance curves based on Navigant-led primary research in the US Midwest in 2012.[13] Though California-specific data was not available to estimate these curves, Navigant considers that the nature of the customer decision-making process is such that the data developed using North American customers represents the best industry-wide data available at the time of this study.

[13] A detailed discussion of the methodology and findings of this research are contained in the *Demand Side Resource Potential Study*, prepared for Kansas City Power and Light, August 2013.

Figure 2-5. Payback Acceptance Curve for AIMS Sectors[14]




#### *2.1.1.5 Calculating Cumulative Market Potential*

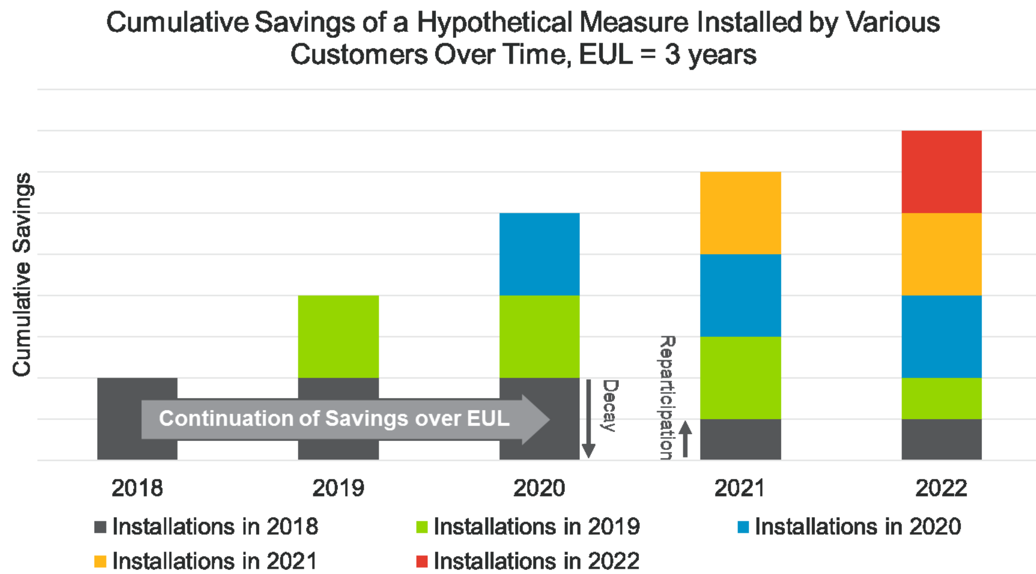
The PG study reports both incremental and cumulative savings. In the recent past, IOU goals have been based on incremental savings only, while cumulative savings was used to inform the CEC demand IRP. Cumulative savings represent the total EE program savings from measures installed since a start year and that are still active in the current year. Active savings are calculated by accounting for the following:

- Decay of savings as measures reach the end of their useful lives
- C&S that come into effect over time

Unlike annual savings, cumulative savings include savings from re-participants. Incremental savings only consider that from first-time adopters. Sustained savings from re-adoptions need to be counted in cumulative savings for the demand forecast. The PG Model assumes re-participants re-adopt measures at the same rate as new participants, consistent with the 2017 Study. The calculation of cumulative savings is illustrated in Figure 2-6.

[14] Sourced from Navigant analysis of data contained in *Demand Side Resource Potential Study* prepared for Kansas City Power and Light, August 2013.

**Figure 2-6. Cumulative Savings Illustration**



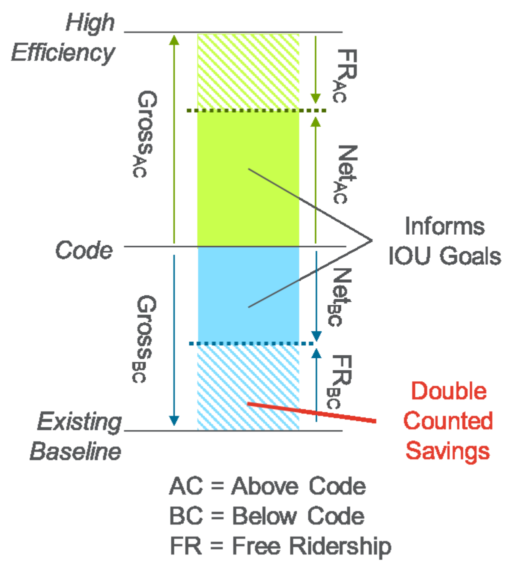

### *2.1.1.6 Net-to-Gross for AR Measures*

The PG study is required to avoid double counted savings between C&S and below code rebate programs. These are the below code savings generated from rebated equipment that would be realized even in the absence of program administrator rebate programs. This savings would occur as equipment would naturally turn over and be replaced with code-compliant equipment. These savings are already embedded and accounted for in the CEC demand forecast; thus, further decrementing the forecast with this savings would be double counting. The PG study takes the approach of attempting to remove double counted savings from the market potential (which informs IOU goals).

The first step the PG study takes in avoiding double counting is to target old equipment when considering below code potential. This is equipment that is not turning over on a regular basis. The remainder of equipment that is turning over on a regular basis has its below code savings already captured through C&S.

The next step in avoiding double counted savings is to identify free ridership of below code savings. This is illustrated in Figure 2-7. Below code free ridership implies that customers were not necessarily influenced by the IOU rebate to come up to code but were influenced by other outside factors. This requires the PG study to apply a net-to-gross (NTG) ratio to below code savings.

**Figure 2-7. Below Code NTG Illustration**




Determination of the below code NTG ($NTG_{BC}$) is not a simple task as no data exists to inform this process. Recent CPUC guidance is to assume below code NTG is the same as above code NTG until additional data becomes available.

### *2.1.2 Whole Building Packages*

Whole building packages are modeled the same way as rebated technologies with one exception. Technical and economic potential results are not presented as they are duplicative with the technical and economic potential of rebated technologies.

### *2.1.3 Industrial and Agriculture Custom Measures and Emerging Technologies*

Custom measures and emerging technologies for the industrial and agricultural sectors used Equation 2-3 to calculate incremental market potential.

**Equation 2-3. General Equation for Calculating Incremental Market Potential for Generic Custom and Emerging Technologies**

$$Incremental\ Market\ Potential = Population \times Applicability\ Factor \times Unit\ Energy\ Savings \times Penetration\ Rate$$

Where:

- **Population** is a global input that is represented as the total energy consumption by subsector within the industrial and agriculture sectors.
- **Applicability Factor** represents eligibility and other program-specific variables that are applied at the subsector level.
- **Unit Energy Savings** represents the percent savings expected from customers adopting technologies at the subsector level.

- **Penetration Rate** represents annual new participation and varies over time; it can also vary by scenario for emerging technologies. Penetration rate is applied at the market sector level.

Emerging technologies were screened for consideration based on an eight-level screening process considering the following factors:

- Relevance to the industrial and agricultural sectors
- Relevance by North American Industry Classification System (NAICS) segment
- End-use application
- Type of fuel savings
- Potential energy savings percentage
- Impact potential (including technical and market potential, risks, and non-energy benefits)
- Segment energy consumption trends
- Segment market trajectory

The emerging technologies that passed the screening criteria were used to derive emerging technology UES values grouped by market segment (e.g., petroleum, food processing, etc.) using the methodology defined in Appendix F. Emerging technology UES is represented as a percent savings relative to the total building energy consumption. It is meant to reflect the combination of available emerging technologies that pass the screening process for each sector and segment rather than represent individual technologies. UES is estimated based on multiple factors listed below Equation 2-4.

**Equation 2-4. UES Equation for Emerging Technologies**

$$UES = T_e \times E_{i,j} \times MT_j \times TW_j$$

Where:

| | |
|---|---|
| $e$ | = subscript indicating the specific emerging technology |
| $i$ | = subscript indicating the specific end-use and fuel type |
| $j$ | = subscript indicating the market subsector and NAICS segment |
| $T_e$ | = technology energy savings percentage for emerging technology, *e,* by end-use application |
| $E_{i,j}$ | = percentage of total energy consumption by subsector *j* energy attributable to end-use *i* |
| $MT_j$ | = market trajectory for sector *j* |
| $TW_j$ | = segment energy consumption trend weight for sector *j* |

The factors that make up the UES include the following:

- Each emerging technology has a unique technology energy savings percentage, $T_e$
- California market data defines the sector end-use percentage of total energy consumption, $E_{i,j}$

- The market trajectory for each sector, $MT_j$, is a value between 0 and 1, indicating if the sector is likely to move offshore (0.33), close to tipping point of moving offshore (0.67), or likely to remain in the US (1)[15]
- The segment energy consumption trend weight, $TW_j$, is a value between 0 and 1, indicating the trend of energy consumption of each sector over time based on an analysis provided by the CEC shows electricity consumption trend for various industries from 1990 through 2015

Section 3.5 discusses the data inputs for this equation.

Industry standard practices (ISPs) are not forecast to impact the potential from custom measures and emerging technologies. ISPs are technology- and segment-specific, while custom programs and emerging technologies as forecast in this study do not contain technology-specific information to allow application of ISPs.

### *2.1.4 Behavior, Retrocommissioning, and Operational Efficiency (BROs)*

For the purposes of this study, the Navigant team defines behavior-based initiatives as those providing information about energy use and conservation actions to drive customer actions rather than financial incentives, equipment, or services to support customer investment. The market potential modeled for these initiatives is incremental savings from equipment change-outs.

#### *2.1.4.1 Energy and Demand Savings*

Equation 2-5 is the general equation for the BROs potential model. Each of the components are described below.

**Equation 2-5. General Equation for Calculating Incremental Market Potential for BROs**

$$\begin{aligned}&Incremental\ Market\ Potential\\&\qquad = Population\ \times\ Applicability\ Factor\ \times\ Unit\ Energy\ Savings\ \times\ Penetration\ Rate\end{aligned}$$

Where:

- **Population** is a global input that can be represented in two ways: number of homes and square feet of floor space or sector energy consumption.
- **Applicability Factor** represents eligibility and other program-specific variables, including existing saturation that precludes customers from participating in future IOU interventions.
- **Unit Energy Savings** represent the savings expected from participants and can also be represented in two ways: kWh and therms or percentage of consumption.
- **Penetration Rate** represents participation and varies over time and by scenario (reference or aggressive). This reflects both the utility-driven rollout and the customer uptake of the program, depending on the nature of the program.

The initial penetration rates are based on existing levels of participation (either for the California IOUs for existing programs or the program from which data was drawn and applied to the California IOUs'

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[15] Sirkin, H. et al. *U.S. Manufacturing Nears the Tipping Point*, The Boston Consulting Group, March 2012.

territories). The forecasts are the result of professional judgement based on program operations and whether participation is utility driven (opt out) or customer driven (opt in).

The potential for double counting among BROs programs was addressed in the characterization of programs in the same sector. The Navigant team adjusted penetration and applicability to avoid the double counting of savings.

This effort does not examine programs that focus on demand reduction (e.g., DR) but does include demand savings from the characterized BROs programs using Equation 2-6.

**Equation 2-6. General Equation for Calculating BROs Demand Savings**

$$Incremental\ Market\ Potential\ (kW) = Incremental\ Market\ Potential\ (kWh)\ \times\ Peak\ to\ Energy\ Ratio$$

#### *2.1.4.2 Costs*

Similar to demand savings, utility program costs are calculated from the energy savings in Equation 2-5. The cost factor in Equation 2-7 is a unit energy cost expressed in either dollars per kWh or dollars per therm. For programs that save both electricity and gas, it was sometimes possible to divide the costs by fuel type; however, in instances where this was not possible, all costs were assigned to one fuel type to avoid double counting costs.

**Equation 2-7. General Equation for Calculating BROs Program Costs**

$$Program\ Cost = Incremental\ Market\ Potential\ \times\ Cost\ Factor$$

### *2.1.5 Codes and Standards*

C&S impacts on EE potential are modeled two ways:

- C&S impacts the code baseline for IOU-rebated measures; as C&S becomes more stringent in the future, above code savings claimable by IOU programs decrease. This is discussed further in Section 2.1.1.2.
- IOUs can claim a portion of savings from C&S that come into effect through the IOU C&S advocacy programs. This section describes the calculation of IOU-claimable savings from C&S.

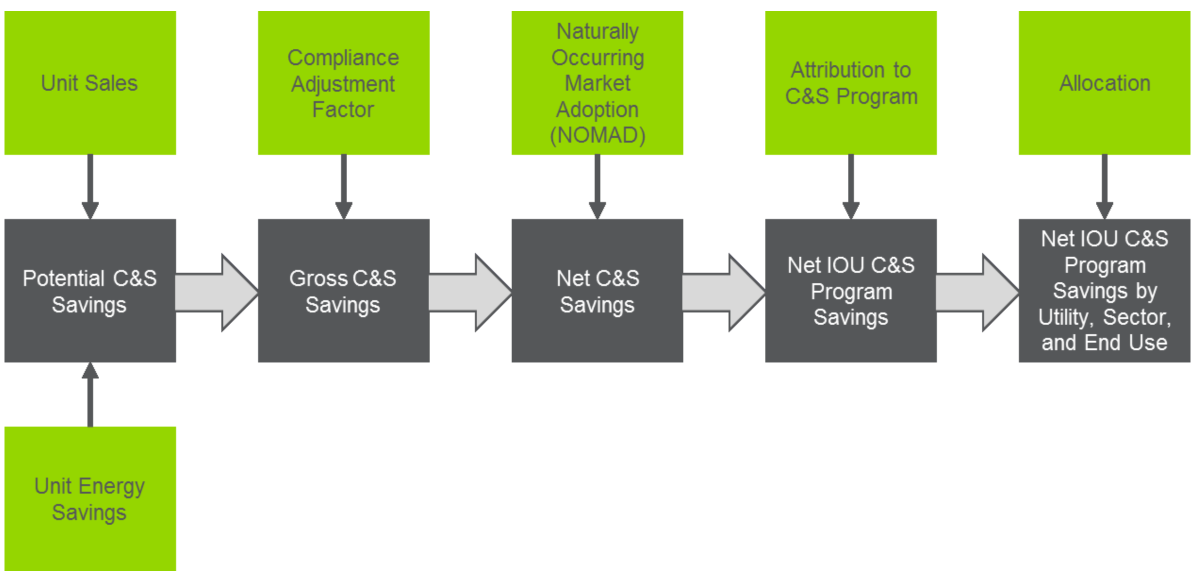
This study calculates the estimated savings of C&S in multiple formats, each for a different use:

- **Net C&S savings** are the total energy savings estimated to be achieved from the updates to C&S since 2006. Net savings calculations account for naturally occurring market adoption (NOMAD) of code-compliant equipment and are used to inform demand forecasting, procurement planning, and tracking against GHG targets. This informs the CEC forecast of AAEE and SB350 target setting.
- **Net IOU C&S program savings** identifies the portion of the net C&S savings that can be attributed to the advocacy work of the IOU's C&S program. This result is used to inform the IOU's program goals.

The modeling methodology of C&S savings was based on the Integrated Standards Savings Model (ISSM)[16] developed by Cadmus and DNV GL and used by the CPUC in C&S program evaluation. The Navigant team replicated the methodology of ISSM in the PG Model for use in this study. The process of calculating net C&S savings and net IOU C&S program savings is illustrated in Figure 2-8. Key components of the calculation listed in Figure 2-8 include the following:

- **Unit sales:** Unit sales are the assumed baseline units sold each year for each measure. They represent the expected population of code-compliant or standard-compliant equipment adopted.
- **UES:** UES are the energy savings (in kWh, kW, or therms) relative to the previous code or standard for the new compliant equipment.
- **Compliance adjustment factor (CAF):** CAF is the baseline assumption for the rate at which the population complies with codes or standards.
- **NOMAD:** The naturally occurring market adoption is the fraction of the population that would naturally adopt the code-compliant or standard-compliant measure in the absence of any code or standard.
- **Attribution:** IOU attribution is the portion of gross C&S savings in California that can be claimed by IOU code support programs.
- **Allocation factors:** Allocation factors are the fraction of the statewide C&S savings that occur in each IOU territory. Additional allocation factors assumed by the Navigant team break down the savings into sectors and end uses.

**Figure 2-8. C&S Savings Calculation Methodology**




The 2019 Study continued to use no layering when analyzing net IOU attributable C&S savings from evaluated C&S. Layering issues were not addressed for unevaluated future C&S.

[16] Cadmus and DNV GL. *Integrated Standards Savings Model (ISSM)*. 2017.

### *2.1.6 Financing*

Financing has the potential to break through several market barriers that have limited the widespread market adoption of cost-effective EE measures. The PG Model is able to estimate the added effects of introducing EE financing on EE market potential and how shifting assumptions about financing affect the potential energy savings.

No updates relative to the 2017 Study have been made to the methodology or data inputs related to financing in the 2019 Study. Additional details on the methodology and data inputs can be found in Appendix G.

## 2.2 Calibrating Rebated Technologies and Whole Building Approaches

SB350 directed the CPUC to adopt goals based on EE potential studies that are not restricted by previous levels of utility EE savings. However, this does not mean that a potential study model should not be calibrated.

Like any model that forecasts the future, the PG Model faces challenges with validating results, as there is no future basis against which one can compare simulated versus actual results. Calibration, however, provides both the developer and recipient of the model results with a level of comfort that simulated results are reasonable. Calibration is intended to achieve the following:

- Anchors the model in actual market conditions and ensures that the bottom-up approach to calculating potential can replicate previous market conditions.
- Ensures a realistic starting point from which future projections are made.
- Accounts for varying levels of market barriers and influences across different types of technologies. The model applies general market and consumer parameters to forecast technology adoption. There are often reasons why markets for certain end uses or technologies behave differently than the norm—both higher and lower. Calibration offers a mechanism for using historic observations to account for these differences.

The calibration process is not a regression of savings or spending (not drawing a future trend line of savings based on past program accomplishments). Rather, calibration develops parameters that describe the customer decision-making process and the velocity of the market based on recent history. Once these parameters are set, the model uses them as a starting point for the forecast period.

The PG Model was calibrated in two steps. First, the Navigant team conducted a draft calibration based on historic data from 2013 through 2016. Second, the team reviewed the draft-calibrated results with stakeholders to incorporate effects post 2017 and the collective insights of stakeholders on how the future may differ from the past.

Step 1 calibrated by reviewing portfolio data from 2013 through 2016[17] to assess how the market has reacted to program offerings in the past. The calibration starts in 2013 because a key input to the model

[17] Calibration extends through 2016 rather than 2017 or 2018 due to the timeline constraints placed on this study. The 2017 model and study was set up to extract and process calibration data from the CPUC's EEStats website. EEStats provides data up through 2016. Program data (including program plans) for 2017 and beyond are housed on the CPUC's CEDARS website. Mining data from CEDARS under the short timeline of this project was not possible.

(equipment saturation data) was based on data collected in the 2012-2013 timeframe. Thus, the model must begin in the same year that its equipment stock data begins.

Step 2 allows for calibration to account for more recent changes to programs. The Navigant team held a workshop on March 21, 2019 to present preliminary draft results of the residential, commercial, and industrial sectors to stakeholders. Following the presentation was a discussion of the following:

- Stakeholder impressions/reactions to the magnitude of the savings and breakdown across different end uses
- Stakeholder input on future trends not captured during the historical calibration
- Stakeholder insights regarding specific sectors/end uses that will be significantly impacted by program changes (positive or negative)
- Defensible reasoning to support any suggested changes

The Navigant team used inputs from this process to inform refinements to the modeling parameters that result in the final calibrated forecast. For more details on calibration, please see 5.

## 2.3 Scenarios

This study continues to forecast multiple scenarios of market potential to inform the goal setting process. Scenario development in this study continues to follow the same framework as the 2017 Study.

The 2019 Study developed five scenarios that inform the CPUC's goal setting process:

- One reference scenario that stems directly from the calibration process
- Four alternate scenarios (informed by stakeholder input)

Additional scenario analysis will be conducted as part of the AAEE analysis after the PG study is finalized. AAEE scenarios feed into the CEC's IEPR and are built around the adopted IOU goals and informed by PG scenarios. AAEE scenarios are able to consider additional variables and policy context and, most importantly, do not impact IOU goals.

This study considers scenarios primarily built around policies and program decisions that are under control of the CPUC and IOUs collectively; these are referred to as internally influenced variables. Externally influenced variables were not considered in scenarios that inform the goals. External variables are those that the CPUC and IOUs collectively have no control over. A list of example internally and externally influenced variables can be found in Table 2-3..

**Table 2-3. Variables Affecting EE Potential**

| Internally Influenced | Externally Influenced |
|---|---|
| • C-E test<br>• C-E measure screening threshold<br>• Incentive levels<br>• Marketing and outreach<br>• BROs customer enrollment over time<br>• IOU financing programs | • Building stock forecast<br>• Retail energy price forecast<br>• Measure-level input uncertainties (UES, unit costs, densities)<br>• Non-IOU financing programs<br>• Enacting of future C&S |

Additional details on each of the internally influenced variables can be found in Table 2-4..

**Table 2-4. Internally Influenced Variables Considered for Scenario Setting**

| Lever | Description | Potential Impact Applicability | |
|---|---|---|---|
| | | Economic | Market |
| **C-E test** | Different C-E screening tests or thresholds yield different amounts of economic potential and cause the market potential model to incentivize different sets of measures. These only apply to rebate programs (excluding the low income program). Screening threshold applies to individual measures (not the portfolio as a whole). | ✔ | ✔ |
| **C-E measure screening threshold** | | ✔ | ✔ |
| **Incentive levels** | Varying incentive levels will change both the C-E of measures and their value proposition to customers. | ✔ | ✔ |
| **Marketing and outreach** | Varying marketing and outreach levels impacts the rate at which technologies are adopted by customers. | | ✔ |
| **BROs program assumptions** | Enrollment in BROs programs is an input vector. Navigant can assume a conservative rollout (reference) or an aggressive rollout of BROs programs. | | ✔ |
| **Financing programs** | IOU financing programs help reduce the cost burden associated with efficient measure adoption. | | ✔ |

The study presented this scenario framework to stakeholders on February 21, 2019, and stakeholders were invited to provide feedback.[18]

Based on stakeholder feedback, the Navigant team worked with CPUC staff to develop scenarios to consider in the goal setting process. Each of the internally influenced variables in Table 2-5. is expected to have an impact on the forecast of EE potential. The combined impact of these variables represents a scenario. The final selected scenarios are listed in Table 2-5..

**Table 2-5. Final Scenarios for EE Potential – Summary**

| Lever | Reference | Alternative 1 | Alternative 2 | Alternative 3 | Alternative 4 |
|---|---|---|---|---|---|
| **C-E test** | TRC | TRC | TRC | TRC | TRC |
| **C-E measure screening threshold** | 1.0 for all measures | 0.85 for all measures | 1.25 for all measures | 1.0 for all measures | 0.85 for all measures |
| **Incentive levels** | Capped at 50%* | Capped at 50%* | Capped at 50%* | Capped at 50%* | Capped at 75%** |
| **Marketing and outreach** | Default calibrated value | Default calibrated value | Default calibrated value | Increased marketing strength | Increased marketing strength |
| **BROs program assumptions** | Reference | Reference | Reference | Aggressive | Aggressive |
| **Financing programs** | No modeled impacts | No modeled impacts | No modeled impacts | No modeled impacts | IOU financing programs broadly available to res and com customers |

*Incentives are set based on a $/kWh and $/therm basis consistent with existing IOU programs; incentives are capped at 50% of incremental cost.
**Incentives are assumed to be 1.5 times higher than what current IOU programs are offering on a $/kWh and $/therm basis, capped at 75% of incremental cost.

The five scenarios can be interpreted as follows:

- The **Reference** scenario represents business as usual and the continuation of current policies. The C-E threshold is set to 1.0 in response to the hypothesis that highly cost-effective measures (such as commercial LED lighting) are moving to standard practice. Previously these highly cost-effective measures would balance out any measures with poor TRC and ultimately result in a portfolio that is cost-effective overall. Losing savings from commercial LEDs may bring down the overall portfolio TRC. Thus, in response, the model excludes individual measures below a TRC of 1.0 to ensure the overall portfolio has a TRC greater than 1.0.
- **Alternative 1** is like the Reference scenario except for decreasing the C-E screening threshold to 0.85 (consistent with the 2017 Study for non-emerging technologies). This would allow measures that are less cost-effective into the forecast. Current and past EE portfolios similarly included

[18] Slides and detailed stakeholder feedback available at: https://pda.energydataweb.com/#!/documents/2133/view

measures with low TRC. This alternate would test what would happen if reasonably cost-effective measures below 1.0 TRC were included in the forecast.

- **Alternative 2** is like the Reference scenario except for increasing the C-E screening threshold to 1.25. This would ensure the overall portfolio of resource programs will have a TRC greater than 1.25.
- **Alternate 3** builds upon the Reference scenario by simulating a more aggressive program design from program administrators. BROs programs are assumed to be aggressive, and program administrators are assumed to increase their marketing and outreach effort to better drive customers to rebate programs.
- **Alternate 4** is the most aggressive of all the scenarios modeled. It builds upon Alternate 3 by lowering the TRC threshold to 0.85, increasing incentives, and making financing broadly available to the residential and commercial sectors. The resulting portfolio simulated by this scenario may not be possible under the current policy framework (e.g., portfolio C-E targets or budget limits).

# 3. DATA SOURCES

The data sources relied on in the 2019 Study are vast and varied. Throughout the study, the Navigant team sought to rely on CPUC-vetted products as much as possible. However, in several cases, the team needed to seek alternate data sources where CPUC resources did not provide the necessary information. This section describes the data update process and sources for key topic areas.

## 3.1 Global Inputs

Global inputs are macro-level model inputs that are not specific to any measure but rather apply to market segments or sectors. The Navigant team reviewed the data source for each of these inputs to ensure that the most recent data is used for the 2019 Study. Table  provides an overview of all global inputs within the 2020 model and their data source. Each item is discussed in further detail in the subsections that follow.

**Table 3-1. Overview of Global Inputs Updates and Sources**

| Global Input *(Description)* | Data Source for Update |
|---|---|
| **Retail Rates** *($/kWh, $/therm)*<br>**Consumption Forecasts** *(GWh, MW, and MMtherms)*<br>**Building Stocks** *(Households, floor space, consumption)* | CEC – *2017 Integrated Energy Policy Report (IEPR) Update and Demand Forecast Forms.* Adopted Feb. 2017.<br>Excel Demand Forecast Forms available at: *http://www.energy.ca.gov/2017_energypolicy/documents/*<br>CPUC – *California Energy Consumption Database (ECDMS).* Accessed Oct. 2018. |
| **Avoided Costs** *(Avoided energy and capacity costs)* | CPUC – *Cost Effectiveness Tool.* Accessed Oct. 2018. |
| **Historic Program Accomplishments** *(Used for calibration)* | CPUC – Energy Efficiency Full Program Cycle (2013-2016) data. Download at: *http://eestats.cpuc.ca.gov/Views/EEDataShelf.aspx* |
| **Non-Incentive Program Costs** | CPUC – California Energy Data and Reporting System (CEDARS) (2018-2019) Data. Download at: *https://cedars.sound-data.com* |

### *3.1.1 Retail Rates and Consumption Forecasts*

The CEC's IEPR, which includes a forecast that is updated annually, is the source for retail rates and consumption forecasts in the 2019 Study. The Navigant team used the 2017 IEPR for both electric and gas rates and forecasts.

Consumption forecasts in the IEPR are shown by the CEC's eight planning areas, which differ slightly from the IOU service territory area. Some of the CEC planning areas include the territories of small publicly owned utilities (POUs) in California. Therefore, an adjustment is needed. Using data on service territory and planning area sales for 2017, the team calculated ratios to adjust the planning area consumption (found within IEPR) down to each IOU's actual service territory consumption for both PG&E

and SCE. These ratios, with the service territory consumption based on the 2017 quarterly fuel energy reports (QFER), are referred to as service territory to planning area adjustment ratios and are detailed in Table 3-2.. The CEC planning area for San Diego directly maps to the SDG&E service territory, so there is no need to calculate an adjustment ratio for SDG&E.

**Table 3-2. 2017 IEPR Electric Service Territory to Planning Area Adjustment Ratios**

| IOU | Residential | Commercial | Industrial | Mining | Agriculture | Street Lighting |
|---|---|---|---|---|---|---|
| PG&E | 96.9% | 86.4% | 89.1% | 90.1% | 86.6% | 90.8% |
| SCE | 93.4% | 89.0% | 88.9% | 95.6% | 67.7% | 93.7% |

*Source: California Energy Commission, 2018*

Most POUs in California do not offer any gas service (only the City of Palo Alto and Island Energy offer natural gas service). It is estimated that California IOUs sell approximately 99% of the state's natural gas. However, there are some exceptions, notably SMUD in PG&E territory. To obtain service territory consumption values, Navigant staff used 2016 data from the CEC's Energy Consumption Database (ECDMS), shown in Table 3-3..[19]

**Table 3-3. 2017 IEPR Gas Service Territory to Planning Area Adjustment Ratios**

| IOU | Residential | Commercial | Industrial | Mining | Agriculture | Street Lighting |
|---|---|---|---|---|---|---|
| PG&E | 100.0% | 98.4% | 99.8% | 99.8% | 99.8% | N/A |
| SCG | 100.0% | 97.5% | 99.6% | 9.19% | 97.9% | N/A |

*Source: California Energy Commission, 2018*

While most of the adjustment ratios are close to or at 100%, SCG mining is 9.19% based on service territory sales found in the ECDMS. Many of the largest oil and gas extraction companies in SCG's planning area purchase gas directly from the pipeline companies. The service territory to planning area adjustment calculation must remove the gas sales that are attributed to those large oil and gas companies.

These ratios were applied to both the sales forecast and the building stocks for electric and gas impacts.

### *3.1.2 Building Stocks*

Building stocks are the total population metrics of a given sector, though represented by different metrics for most sectors. Residential building stocks are based on the number of households in an IOU's service territory. Commercial building stocks are represented by total floor space for each commercial building type. Industrial and agricultural building stocks are represented by energy consumption. Mining and street lighting stocks are the number of pumps and street lights, respectively. The residential, commercial, industrial, and agriculture building stock metrics are derived from the CEC's IEPR.

The model requires building stocks by sector, scenario, and utility for the timeframe 2013-2030.

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[19] California Energy Consumption Database. Accessed October 2018: http://ecdms.energy.ca.gov/

The IEPR organizes building stock data into the eight electric planning areas determined by the CEC. To translate these IEPR results to the PG Model and split them by utility, the Navigant team worked with the CEC to map CEC planning areas to the IOU service territories, as listed in Table 3-4..

**Table 3-4. Mapping CEC Planning Areas to IOU Service Territories**

| CEC Electric and Gas Planning Areas to Utilities | | | |
|---|---|---|---|
| **CEC Forecasting Climate Zones** | **Electric Planning Area Number** | **Electric Planning Area Utilities** | **Natural Gas Planning Area Utilities** |
| Climate Zone 1 | 1 - PG&E | PG&E | PG&E |
| Climate Zone 2 | | | |
| Climate Zone 3 | | | |
| Climate Zone 4 | | | |
| Climate Zone 5 | | | |
| Climate Zone 6 | | | |
| Climate Zone 7 | 2- SCE | SCE | SCG |
| Climate Zone 8 | | | |
| Climate Zone 9 | | | |
| Climate Zone 10 | | | |
| Climate Zone 11 | | | |
| Climate Zone 12 | 3 - SDG&E | SDG&E | SDG&E |
| Climate Zone 13 | 4 - NCNC | SMUD | PG&E |
| Climate Zone 14 | | TID | |
| Climate Zone 15 | | Other (Modesto, Redding, Roseville, Trinity, and Shasta Lake) | |
| Climate Zone 16 | 5 - LADWP | LADWP | SCG |
| Climate Zone 17 | | | |
| Climate Zone 18 | 6 - Burbank/Glendale | Burbank/Glendale | |
| Climate Zone 19 | 7 - IID | IID | |
| Climate Zone 20 | 8 - Valley Electric | Valley Electric | |

*Source: California Energy Commission, 2017*

### *3.1.3 Historic Rebate Program Activity*

The historic rebate program achievements for each of the IOUs are important inputs for calibrating the forecast of rebate programs. The CPUC maintains the Energy Efficiency Statistics (EEStats) portal, an online resource that collects program achievement data, for public use. A spreadsheet of 2013-2015 program achievement data and a spreadsheet of 2016 achievement data are available for download on this website. These datasets include ex ante and evaluated program savings, expenditures, C-E, and emissions for EE programs statewide. For the 2019 Study, the team used this dataset to compute portfolio net and gross savings for each sector and utility.

Table 3-5. provides the 2013-2016 gross ex post savings. Some program savings were not modeled as a rebate program and those savings are excluded from this analysis. For example, residential home energy reports (HERs) and retrocommissioning fall under the definition of the BROs and were removed to prevent double counting savings.

**Table 3-5. 2013-2016 IOU-Reported Portfolio Gross Program Savings**

| IOU | Spending ($ Millions) | | Energy Savings (GWh) | | Gas Savings (MM therms) | |
|---|---|---|---|---|---|---|
| | RES | COM | RES | COM | RES | COM |
| PG&E | 231.64 | 584.35 | 688.29 | 1,190.74 | -0.63 | 17.93 |
| SCE | 333.27 | 553.45 | 1,080.44 | 1,422.96 | N/A | N/A |
| SCG | 77.83 | 41.06 | N/A | N/A | 15.28 | 15.77 |
| SDG&E | 82.82 | 158.61 | 229.40 | 363.03 | -1.00 | 3.53 |

*Source: CPUC – Energy Efficiency Full Program Cycle (2013-2016) Data*

Additional discussion of the calibration process can be found in 5.

### 3.1.4 Non-Incentive Program Costs

Non-incentive program costs come from the 2018-2019 Summary Reports Data on the CPUC's CEDARS portal. For the PG Model, the Navigant team determined program costs per unit of kWh or therm, by sector. This is facilitated by the EEStats data, where program costs for each program and measure line are already listed. In EEStats, program costs combine administrative costs, marketing costs, implementation (customer service) costs, overhead, and evaluation, measurement, and verification, (EM&V) costs. Note that interactive effects are excluded prior to calculating these costs.

Table 3-6. provides an overview of the non-incentive program costs based on gross reported savings. The displayed AIMS program cost is an average of the individual agriculture, industrial, mining, and street lighting costs calculated.

**Table 3-6. Non-Incentive Program Costs Summary**

| IOU | Electric Savings ($/Gross kWh) | | | Gas Savings ($/Gross therm) | | |
|---|---|---|---|---|---|---|
| | RES | COM | AIMS | RES | COM | AIMS |
| PG&E | $0.09 | $0.10 | $0.08 | $2.59 | $2.92 | $2.38 |
| SCE | $0.06 | $0.22 | $0.18 | N/A | N/A | N/A |
| SCG | N/A | N/A | N/A | $1.15 | $1.14 | $0.72 |
| SDG&E | $0.14 | $0.07 | $0.04 | $4.02 | $1.15 | $1.88 |

*Source: CPUC – California Energy and Data Reporting System (CEDARS) - 2018-2019 Program Filing Data*

### 3.1.5 Avoided Costs

Avoided costs place an economic value on the amount of energy and GHG emissions that is saved by implementing an energy-saving measure. Avoided costs are a key input to the calculation of cost-effectiveness.

To determine avoided costs, the Navigant team used version 18.1 of the Cost-Effectiveness Tool (CET), a calculator commissioned by the CPUC.[20] The team used the 2019 vintage of the avoided cost data. Post-processing of the CET calculator data resulted in a dataset that displays total avoided costs for 2018-2048 by IOU, sector, end-use category, and sub-end-use category.

Electric avoided costs for the PG Model are the sum of the avoided costs of generation, transmission and distribution (T&D), and carbon from the CET. Carbon in the CET is expressed in tons/kWh, so the Navigant team needed to multiply this data by the cost of carbon. Gas-avoided costs are the sum of the avoided costs of generation and T&D as reported by the CET. The CET embeds the cost of carbon in its valuation of gas generation avoided cost.

In March 2018, the CPUC issued a Staff Proposal that included an avoided cost calculator with costs per ton of carbon for each year from 2018 to 2030.[21] The carbon cost is the sum of the cap and trade allowance price and a GHG adder.[22] The Navigant team assumed that after 2030 the real cost of carbon remained constant.[23]

**Table 3-7. Costs of Carbon, 2018-2050**

| Year | Carbon Cost (nominal $/ton) | Carbon Cost (real 2016 $/ton) |
|---|---|---|
| 2018 | $63.01 | $60.21 |
| 2019 | $71.23 | $66.53 |
| 2020 | $79.79 | $72.86 |
| 2021 | $88.71 | $79.18 |
| 2022 | $98.00 | $85.50 |
| 2023 | $107.67 | $91.83 |
| 2024 | $117.73 | $98.15 |
| 2025 | $128.19 | $104.46 |
| 2026 | $139.07 | $110.79 |
| 2027 | $150.39 | $117.11 |
| 2028 | $162.16 | $123.43 |
| 2029 | $174.38 | $129.75 |
| 2030 | $187.09 | $136.08 |
| 2031 | $191.39 | $136.08 |
| 2032 | $195.80 | $136.08 |

[20] CPUC. "CET Desktop The Cost Effectiveness Tool." Accessed Oct. 2018. http://eega.cpuc.ca.gov.

[21] CPUC. "Cost-effectiveness Air Quality Adder Data." 2018. http://www.cpuc.ca.gov/General.aspx?id=5267

[22] Horii, Brian, Eric Cutter, Zach Ming. *Avoided Costs 2018 Update*. 2018. Pg. 39. http://www.cpuc.ca.gov/General.aspx?id=5267

[23] The forecast assumes a 2.3% inflation rate when converting real 2016 dollars into nominal cost.

| Year | Carbon Cost (nominal $/ton) | Carbon Cost (real 2016 $/ton) |
|---|---|---|
| 2033 | $200.30 | $136.08 |
| 2034 | $204.91 | $136.08 |
| 2035 | $209.62 | $136.08 |
| 2036 | $214.44 | $136.08 |
| 2037 | $219.37 | $136.08 |
| 2038 | $224.42 | $136.08 |
| 2039 | $229.58 | $136.08 |
| 2040 | $234.86 | $136.08 |
| 2041 | $240.26 | $136.08 |
| 2042 | $245.79 | $136.08 |
| 2043 | $251.44 | $136.08 |
| 2044 | $257.22 | $136.08 |
| 2045 | $263.14 | $136.08 |
| 2046 | $269.19 | $136.08 |
| 2047 | $275.38 | $136.08 |
| 2048 | $281.72 | $136.08 |
| 2049 | $288.20 | $136.08 |
| 2050 | $294.82 | $136.08 |

## 3.2 Residential and Commercial Technology Characterization

The technology characterization step develops the essential inputs that are used in the PG Model to calculate potential. This section provides an overview of the technology selection process for the residential and commercial sectors, describes the fields along which technologies are characterized, lists the data sources and describes how these sources are used for characterization, and directs the reader to the complete database of characterized technologies.

Like the 2017 Study, the 2019 Study uses a technology-based characterization, which characterizes individual technology levels within a technology group. A **technology group** includes multiple technologies with different efficiency levels that compete for stock replacement under an end use. Technology group is also commonly referred to as competition group. For example, residential ACs with different efficiency levels (SEER 13, SEER 16, SEER 21, etc.) are considered a single technology group termed residential air conditioners.[24]

[24] This is different from the 2015 version and earlier versions of the study, which classified measures defined by a base technology upgrading to an efficient level technology (e.g., SEER 13 to SEER 16 ACs and SEER 13 to SEER 21 ACs were considered two different measures).

### 3.2.1 Technology Selection Process

Given the constrained timeline for this study, the technology selection for the 2019 Study started with the technology list developed for the 2017 Study. The Navigant team undertook a comprehensive technology selection process for the 2017 Study, consisting of the following steps:

1. Developed a comprehensive and universal list of technology groups for consideration in the study.
2. Selected a subset of representative technology groups from the California IOUs' program portfolios that provide the bulk of the savings (98% of the total savings by end use for the residential and commercial sectors).
3. Presented the technology list to stakeholders for review and feedback.
4. Developed a final list of technology groups as well as the full list of individual technologies under each technology group.

For the 2019 Study, the team retained the technology list from the 2017 Study with the following changes:

- Removed the SEER 10 efficiency level from the residential heat pumps and residential air conditioners technology groups (new information from DEER suggests that the average installed heat pump or air conditioner is SEER 13 in the base year of the 2019 Study)
- Added residential advanced lighting controls[25] as an additional efficient level to certain residential lighting technology groups:
    - Lighting fixtures – indoor
    - Reflector lamps – indoor
    - Screw-in lamps – low – indoor
    - Screw-in lamps – high – indoor
    - Specialty lamps – low – indoor
    - Specialty lamps – high – indoor
- Removed residential indoor lighting controls as a separate technology group as this measure is replaced by the above described advanced lighting controls
- Added smart connected power strips as an additional efficient level to the residential advanced power strips technology group
- Added commercial HVAC energy management systems (EMS) as a separate technology group

[25] In the residential sector, advanced lighting controls are assumed to be embedded in the power electronics of the light bulb, and the bulb with advanced controls can be exchanged for a baseline bulb in the same socket or fixture. The embedded controls combine the functionality of four types of controls: dimmers, occupancy sensors, timers, and daylighting/ambient light sensing.

Table 3-8. shows the number of technology groups and individual technologies characterized in the study by end use for the residential and commercial sectors, including technologies under both fuel types (electric and gas).[26]

**Table 3-8. Final List of Technology Groups (with Examples) and Individual Technologies**

| Sector | End Use | Technology Group Examples[27] | Number of Technology Groups | Number of Individual Technologies[28] |
|---|---|---|---|---|
| Residential | Appliances/ Plug Loads | Refrigerators, Pool Pumps, Clothes Dryers | 13 | 43 |
| | Building Envelope | Weatherization, Attic Duct Insulation, Windows | 13 | 39 |
| | HVAC | Air Conditioners, Heat Pumps, Ceiling Fans | 16 | 45 |
| | Lighting | Indoor Screw-In Lamps, Specialty Lamps, Linear Fixtures | 12 | 54 |
| | Water Heating | Electric Water Heaters, Faucet Aerators, Showerhead | 11 | 27 |
| | **Total** | | **65** | **208** |
| Commercial | Appliances/ Plug Loads | Power Strips, Servers, Vending Controls | 14 | 43 |
| | Building Envelope | Ceiling/Roof Insulation, Wall Insulation, Windows | 6 | 19 |
| | Com. Refrigeration | Display Case Motors, Strip Curtains, Anti-Sweat Heat Controls | 8 | 19 |
| | Data Center | Server Virtualization, High Efficiency UPS, CRAC Upgrades | 5 | 10 |
| | Food Service | Electric Convention Ovens, DCV Exhaust Hood, Steamers | 7 | 14 |
| | HVAC | Chillers, Split AC, Mini Split Heat Pumps | 24 | 82 |
| | Lighting | High Bay Fixtures, Lighting Fixtures (Indoor and Outdoor), Indoor Reflector Lamps | 12 | 47 |
| | Water Heating | Electric Storage Water Heaters, Faucet Aerators, Showerhead | 3 | 12 |
| | **Total** | | **79** | **246** |

[26] Please refer to the Measure Input Characterization System (MICS) database for additional details.

[27] The complete list of technology groups is presented in the MICS database.

[28] Note that the technology list does not include whole building packages and BROs interventions. The approach used to select and characterize these measures is discussed in separate sections of this report. Please refer to the MICS database for a complete list of the technologies included in the study.

### 3.2.2 Technology Characterization

Characterizing selected technologies involves developing various inputs for each technology necessary to calculate potential. Table 3-9. summarizes the key items the Navigant team used to characterize the technologies along with brief descriptions.

**Table 3-9. Key Fields for Measure Characterization with Brief Descriptions**

| Items | Brief Description |
|---|---|
| **Technology Description** | Specifies the following for each technology:<br>• Sector<br>• End use<br>• Fuel type<br>• Climate zone<br>• Segment/building type<br>• Replacement type |
| **Energy Use** | Specifies the following for each technology:<br>• Energy use (electric and gas)<br>• Coincident peak demand<br>• Interactive effects |
| **Technology Costs** | Specifies the following for each technology:<br>• Equipment cost<br>• Repair cost (for AR technologies)<br>• Installation cost |
| **Market Information** | Specifies the following for each technology:<br>• Applicability by segment/building type<br>• Density associated with the technology group<br>• Saturation for individual technologies |
| **Other Items** | Includes the following:<br>• Technology lifetime (EUL and RUL)<br>• NTG ratio |

The following subsections describe in detail how the energy use, costs, market information, and other relevant fields were developed and the associated hierarchical list of data sources for this information.

#### 3.2.2.1 Energy Use

Energy use is a key input for technology characterization. The technology-based approach followed in this study implies that the absolute energy use associated with average below code, code, and efficient technologies need to be specified.

Unit energy use is specified in kWh for electric technologies and in therms for gas-fueled technologies. For dual fuel technologies that can achieve both electric and gas savings, such as insulation, both metrics are calculated. Additionally, some technologies have interactive effects. An example is energy efficient lighting, which produces less waste heat than incandescent bulbs and thus has additional HVAC consumption associated with it. The technology characterization template requires these interactive effects to be included.

Electric technologies also require the characterization of coincident peak demand. Effective January 1, 2020, the peak period used to calculate demand impacts in DEER changed per DEER Resolution E-4952, published October 11, 2018. The Navigant team assumed that the demand impacts in DEER 2020 already incorporated this new peak demand period. For demand data not sourced from DEER 2020, the team updated the peak demand impacts to be consistent with the new DEER definitions, leveraging available load shape data and prioritizing the use of DEER load shapes when available.

Table 3-10. lists the data sources for energy use (in hierarchical order) with brief descriptions of the sources.

**Table 3-10. Hierarchy of Data Sources for Energy Use Information**

| Priority | Energy Consumption Source Name | Description | Author | Publication Year |
|---|---|---|---|---|
| 1 | DEER 2020 | Navigant used information from 2019/2020 DEER updates to obtain energy use and coincident peak demand for technologies, wherever available.<br>Lighting energy use was calculated using the lighting calculator tool available at DEER. | CPUC | 2019 |
| 2 | Non-DEER Ex Ante Database | Navigant referred to the Non-DEER ex ante database, available from CPUC staff, to characterize technologies that were not included in DEER. | CPUC | 2016 |
| 3 | IOU Workpapers (with CPUC Disposition) | Navigant referred to the inventory of workpapers published by the California IOUs and referred to approved workpapers for technology characterization, wherever applicable. | California IOUs | Various |
| 4 | California POU Technical Reference Manual (TRM) | Navigant referred to the CMUA TRM for energy use information for applicable technologies. | CalTF | 2015 |
| 5 | California IOU Emerging Technology Reports | Navigant reviewed and researched project/technology reports from the ETCC—a collaborative forum with IOUs and leading member organizations for characterization of emerging technologies. | Emerging Technology Coordinating Council (ETCC), IOUs | Various |
| 6 | IOU Program Data | Navigant referred to the 2016 EEStats database[29] and 2014-Q12016 program savings[30] database from CA IOUs, in case energy use information was not available from the above listed sources. | CPUC, IOUs | 2014-2016 |
| 7 | Non-California source examples:<br>• Regional Technical Forum (RTF) Database | In cases where California-specific sources were not available for energy use information, Navigant referred to the following sources:<br>• Measure-level savings data from evaluated programs in the Pacific Northwest region, available through the RTF. | Northwest Power and Conservation Council (NPCC) | 2015 |

[29] Available at: http://eestats.cpuc.ca.gov/Views/EEDataPortal.aspx

[30] Navigant obtained the database of IOU programs with savings and cost information from Itron under the CPUC's directive.

| Priority | Energy Consumption Source Name | Description | Author | Publication Year |
|---|---|---|---|---|
| | • Navigant Potential Study Database | • Navigant's archive of characterized measure savings from potential studies and projects with other utilities. | Navigant | 2017-2018 |

#### *3.2.2.2 Technology Costs*

The measure characterization database requires specification of equipment costs, labor costs for installation, and repair costs for AR technologies. Information on technology costs were primarily sourced from the California Measure Cost Study, published by Itron in 2012. Some of the other cost data sources are the same as those listed under energy use. Table 3-11. summarizes the data sources used for technology costs.

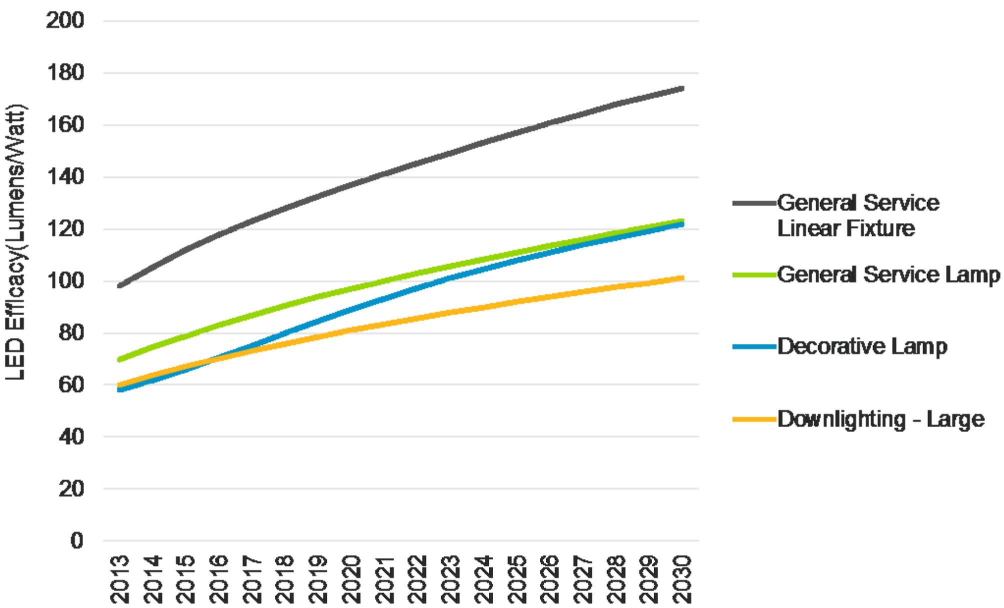
**Table 3-11. Hierarchy of Data Sources for Technology Cost Information**

| Priority | Cost Source Name | Description | Author | Year |
|---|---|---|---|---|
| 1 | California Measure Cost Study | This served as the primary source of information for equipment and installation costs. | Itron | 2012 |
| 2 | DEER | Navigant used information from 2019/2020 DEER updates to obtain equipment and labor costs for technologies, wherever available. For the most part, DEER pulls cost data from the California Measure Cost Study. | CPUC | 2019 |
| 3 | IOU Workpaper (with CPUC Disposition) | Navigant obtained equipment and labor costs from approved California IOU workpapers in cases where the Navigant team referred to these workpapers for obtaining energy use information. | California IOUs | Various |
| 4 | CMUA TRM | Navigant obtained equipment and labor costs from the CMUA TRM in cases where the Navigant team referred to the CMUA TRM for obtaining energy use information. | Cal TF | 2015 |
| 5 | California IOU Emerging Technology Reports | Navigant obtained cost information on emerging technologies from ETCC technology reports, wherever available. | ETCC, IOUs | Various |

| Priority | Cost Source Name | Description | Author | Year |
|---|---|---|---|---|
| 6 | Non-California source examples:<br>• Energy Savings Forecast of Solid-State Lighting in General Illumination Applications[31]<br>• Navigant Potential Study Database | For lighting technologies, Navigant referred to a US Department of Energy (DOE) report authored by Navigant for LED cost data (see discussion following table).<br>In cases where no California-specific source was available for costs, Navigant referred to its internal database of energy efficient technologies for available cost information. | DOE<br>Navigant | 2016<br>2017-2018 |

The Navigant team referred to forecasts from the DOE to obtain LED costs.[32] This was done to incorporate cost projections into the model while maintaining consistency across years. The team used efficacy (lm/W) and price per kilo-lumen ($/klm) projections to determine current and future costs for LEDs. Figure 3-1 and Figure 3-2 graph the projected efficacy and costs of different lamp types of LEDs, respectively, through 2030.

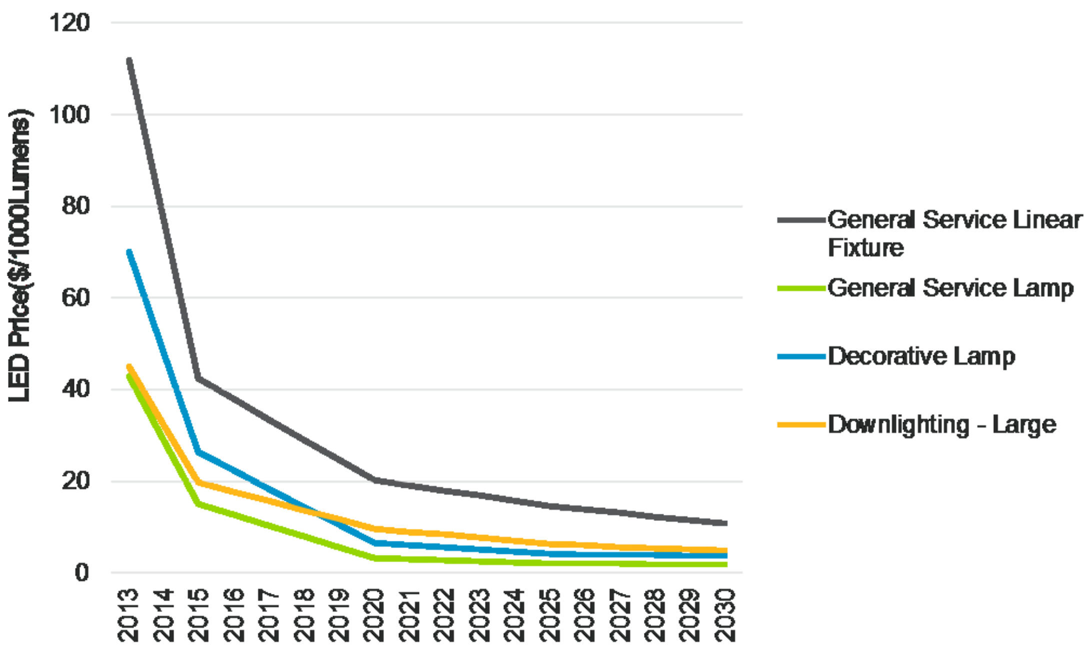
**Figure 3-1. Projected LED Technology Improvements, 2013-2030**




Source: Navigant analysis of DOE data

[31] Downloadable from http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf.
[32] Navigant. *Energy Savings Forecast of Solid-State Lighting in General Illumination Applications*. Prepared for the U.S. DOE. 2016. Downloadable from http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf

**Figure 3-2. Projected LED Cost Reduction Profiles, 2013-2030**




Source: Navigant analysis of DOE data

#### *3.2.2.3 Market Information: Density and Saturation Values*

Density and saturation are two essential calculations of technology characterization.

- Density is a measure of the number of units per building. The potential model uses the density information to determine the number of applicable technology units on the appropriate scaling basis (per household for residential and per square foot for commercial) to scale up the technology stock by segment/building type. Density is specified by technology group and by individual technologies. Density can be expressed as the following (for example): units/home, bulbs/home, fixtures/1,000 square feet, tons of cooling/1,000 square feet, etc.
- Saturation is the share of a specific technology within a technology group, so that the sum of the saturations across a technology group always sums to 100%. Saturation can also be calculated by dividing the individual technology density by the total technology group maximum density.

As an example, Table 3-12. shows the densities and saturations for residential refrigerators in single-family homes in PG&E's service territory.

**Table 3-12. Example of Density and Saturation Calculation**

| Technology Name | Base Year Efficiency Level | Unit Basis | Technology Density (Units per Household) | Technology Saturation |
|---|---|---|---|---|
| Average Below Code Refrigerator | Average Below Code | No. of Refrigerators | 0.155 | 13% |
| Code-Compliant Refrigerator | Code | No. of Refrigerators | 0.590 | 51% |
| ENERGY STAR Refrigerator | Efficient | No. of Refrigerators | 0.405 | 35% |
| **Total** | | | **1.15** | **100%** |

The table shows that an average single-family home in PG&E's territory has 1.15 refrigerators per home, which is the density for refrigerators in single-family homes. The saturations for average below code, code-compliant, and ENERGY STAR refrigerators for single-family homes is 13%, 51%, and 35%, respectively. The saturation changes over time with population growth and stock turnover as more below code stock gets replaced with at code and higher efficiency stock.

Table 3-13. lists the resources used to calculate density and saturation for the residential and commercial sectors in 2017, in order of priority. The Navigant team primarily used California-specific sources for density and saturation data and referred to non-California sources only in cases California-specific sources did not have the required data.

**Table 3-13. Sources for Density and Saturation Characterization**

| Priority | Sources | Description | Author | Year |
|---|---|---|---|---|
| 1 | California Lighting & Appl. Saturation Survey (CLASS) | Residential baseline study of 1,987 homes across California. | DNV GL | 2012 |
| 2 | Commercial Saturation Survey (CSS) | Baseline study of 1,439 commercial buildings across California. | Itron | 2012 |
| 3 | Residential Appliance Saturation Study (RASS)[33] | Residential end-use saturations for 24,000 households in California. | DNV GL (formerly KEMA) | 2009 |
| 4 | Non-California source examples:<br>• Residential Building Stock Assessment (RBSA)<br>• Comm. Building Stock Assessment (CBSA) | RBSA and CBSA survey residential and commercial building stock across the Northwest states (Idaho, Montana, Oregon, Washington). | Northwest Energy Efficiency Alliance (NEEA) | 2014 |
| | • Res. Energy Consumption Survey (RECS)<br>• Comm. Bldg. Energy Cons. Survey (CBECS) | RECS and CBECS are surveys of residential and commercial building stock in the US by region. Used West regional data only. | US DOE | 2009 |
| | • ENERGY STAR Shipment Database | Unit shipment data of ENERGY STAR-certified products collected to evaluate market penetration and performance. | Environmental Protection Agency (EPA) | 2003-2016 |

In addition to the density and saturation values, measure characterization requires specifying the technical suitability or applicability factor (which has a value less than or equal to 1) that defines the share of customers with the physical or infrastructural pre-requisites to install a technology. The applicability factor assumptions are based on data sources, wherever available, and the Navigant team's industry expertise and subject matter expertise in the area.

#### *3.2.2.4 MICS Database*

The MICS database consolidates the information from the measure characterization effort in an Excel spreadsheet that serves as an input to the PG Model. It presents the various dimensions along which measures are characterized as separate fields in the database. The database is publicly available and can be downloaded through the CPUC website.[34]

## 3.3 Whole Building Initiatives

Whole building initiatives aim to deliver savings to residential and commercial customers as a package of multiple efficiency measures that are all installed at the same time. The 2019 Study models whole building initiatives via the technology levels indicated in Table 3-14.. As described in Section 2.1.1.2, the

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[33] Navigant referred to this source only in cases where CLASS and CSS did not have the required data.

[34] http://www.cpuc.ca.gov/General.aspx?id=6442452619

 

technology levels within the technology group include existing baseline, code baseline, and the efficient result of a whole building initiative.

**Table 3-14. Whole Building Technology Levels**

| Technology Group | Residential Technology Level | Commercial Technology Level |
|---|---|---|
| New Construction | Title 24 2008 Code | Title 24 2008 Code |
| | Title 24 2013 Code | Title 24 2013 Code |
| | Title 24 2016 Code | Title 24 2016 Code |
| | Title 24 2019 Code | Title 24 2019 Code |
| | Zero Net Energy (ZNE) | ZNE |
| Retrofit | Existing Building – No Retrofit | Existing Building – No Retrofit |
| | Energy Upgrade CA – Basic | Retrofit – 15% Savings |
| | Energy Upgrade CA – Advanced | - |

*Source: Navigant team analysis, 2019*

The following sections discuss the technology levels used in the 2017 Study. The final values for savings, cost, measure life, and other key model inputs can be found in the MICS spreadsheet.

### *3.3.1 New Construction*

The 2019 Study represents each Title 24 code level as it becomes the baseline for ZNE construction as the efficient measure, with energy consumption in absolute terms and costs represented as incremental to 2008 Title 24 levels. Communications with the CEC indicate that 7% energy savings are expected for residential 2019 Title 24 over 2016 Title 24, and 2% energy savings are expected for commercial 2019 Title 24 over 2016 Title 24. Both are a decrease from the previous study assumption of 10% savings for both sectors.

The Navigant team adjusted the savings for ZNE to account for LEDs becoming standard practice in the residential sector starting in 2020 and the commercial sector starting in 2019. This change to lighting standard practice was not anticipated in the original data sources relied upon for ZNE analysis. The change in commercial buildings was promulgated by DEER Resolution E-4952 in October 2018. There was no official resolution for lighting in residential buildings, but CPUC staff directed Navigant to assume that LEDs will become standard practice in the near future. The Navigant team estimated the percent reduction in savings as equivalent to the percent of building consumption attributed to the lighting end use in the CBEC 2016 Reference Case (the most recent year for which there was CBECC data). This estimate relies on two assumptions: 1) that the percent of savings attributable to lighting is equivalent to the percent of consumption attributable to lighting (i.e., between 10% and 40% depending on the building type and climate zone); and 2) lighting savings would be eliminated from new construction meeting a ZNE building code. In reality, new construction may still have some lighting savings due to controls and lighting types that would not move to a LED standard practice, but Navigant believes this is a conservative approach that avoids double counting of lighting savings that will naturally occur.

#### *3.3.1.1 Commercial*

Table 3-15. provides the sources used to characterize commercial new construction whole building initiatives. These represent the best and usable datasets available to the team at the time of characterization. Of particular value was the data from the 2016 CBECC-Com software, which provided variability by climate zone.

**Table 3-15. Commercial New Construction Whole Building Data Sources**

| Data Category | Data Items | Data Sources |
|---|---|---|
| **Cost** | Incremental Cost of 2013 Title 24 over 2008 Title 24 | California Energy Commission, 2013 Standard Cost Impact Analysis: http://www.energy.ca.gov/title24/2013standards/rulemaking/documents/final_rulemaking_documents/05_Impact_Analysis.pdf |
| | Incremental Cost of 2016 Title 24 over 2013 Title 24 | California Energy Commission, 2016 Notice of Proposed Action: http://www.energy.ca.gov/title24/2016standards/rulemaking/documents/NOPA_title24_parts_01_06.pdf |
| | Incremental Cost of 2019 Title 24 over 2016 Title 24 | Navigant extrapolation based on 2016 Title 24 |
| | Incremental Cost of ZNE over 2013 Title 24 | Calculated using the following:<br>New Building Institute, *Getting to Zero 2012 Status Update: A First Look at the Costs and Features of Zero Energy Commercial Buildings*: http://newbuildings.org/getting-zero-2012-status-update-first-look-costs-and-features-zero-energy-commercial-buildings<br>Comm. RE Specialists, Cost Per Square Foot For New Commercial Construction, 2013<br>Reed Construction Data Inc., RS Means Square Foot Estimator, 2013: http://www.rsmeansonline.com |
| **Energy Consumption and Savings** | 2016 Title 24 Energy Consumption | CEC, CBECC-Com 2016 Std. Design Results, January 2017 |
| | Incremental Energy Savings of 2013 Title 24 over 2008 Title 24 | California Energy Commission, 2013 Impact Analysis: http://www.energy.ca.gov/2013publications/CEC-400-2013-008/CEC-400-2013-008.pdf |
| | Incremental Energy Savings of 2016 Title 24 over 2013 Title 24 | California Energy Commission, 2016 Impact Analysis: http://www.energy.ca.gov/title24/2016standards/rulemaking/documents/15-day_language/impact_analysis/2016_Impact_Analysis_2015-06-03.pdf |
| | Incremental Energy Savings of 2019 Title 24 over 2016 Title 24 | Communications with the CEC, January 2019 |
| | Incremental Energy Savings of ZNE over 2013 Title 24 | ARUP, *The Technical Feasibility of Zero Net Energy Buildings in California*, December 2012 (incorporating changes to lighting standard practice; see previous section) |

#### *3.3.1.2 Residential*

Table 3-16. provides the sources for energy consumption and cost data for residential new construction.

**Table 3-16. Residential New Construction Whole Building Data Sources**

| Data Category | Data Items | Data Sources |
|---|---|---|
| **Cost** | Incremental Cost of 2013 Title 24 over 2008 Title 24 | CEC, 2013 Standard Cost Impact Analysis: http://www.energy.ca.gov/title24/2013standards/rulemaking/documents/final_rulemaking_documents/05_Impact_Analysis.pdf |
| | Incremental Cost of 2016 Title 24 over 2013 Title 24 | CEC, 2016 Notice of Proposed Action: http://www.energy.ca.gov/title24/2016standards/rulemaking/documents/NOPA_title24_parts_01_06.pdf |
| | Incremental Cost of 2019 Title 24 over 2016 Title 24 | Navigant extrapolation based on 2016 Title 24 |
| | Incremental Cost of ZNE over 2013 Title 24 | CEC Draft Title 24 Code Update Analysis provided to Navigant |
| **Energy Consumption and Savings** | Incremental Energy Savings of 2013 Title 24 over 2008 Title 24 | CEC, 2013 Standard Cost Impact Analysis: http://www.energy.ca.gov/title24/2013standards/rulemaking/documents/final_rulemaking_documents/05_Impact_Analysis.pdf |
| | 2013 Title 24 Energy Consumption | CEC, CBECC-Res 2013 Std. Design Results, 2015 |
| | 2016 Title 24 Energy Consumption | CEC, CBECC-Res 2016 Std. Design Results, January 2017 |
| | Incremental Energy Savings of 2019 Title 24 over 2016 Title 24 | Communications with the CEC, January 2019 |
| | Incremental Energy Savings of ZNE over 2013 Title 24 | ARUP, *The Technical Feasibility of Zero Net Energy Buildings in California*, December 2012 (incorporating changes to lighting standard practice; see previous section) |

### 3.3.2 Retrofit

Characterization of both commercial and residential whole building retrofits reflects the encouragement of to-code savings in existing buildings expressed in AB802.

#### 3.3.2.1 Commercial

The 2019 Study follows the approach of the 2017 Study in using a top-down approach with a goal of saving 15% of consumption at the whole building level. This target was selected in response to feedback collected during the 2017 Study that indicated that whole building retrofits needed to achieve 15% savings to be able to differentiate savings from noise when using normalized metered energy consumption (NMEC) methods and to reflect deeper energy savings from multi-measure approaches.[35]

In the 2017 Study, Navigant verified that this level of savings could be achieved by addressing cooling, ventilation, lighting, and refrigeration electric end uses and heating, water heating, and food service gas end uses.[36] The Navigant team derived the savings distribution across the end uses by starting with the percent savings exhibited by each end use in the 2013-2015 California EE portfolio and iterating to

[35] Decision Approving 2013-2014 Energy Efficiency Programs and Budgets, p. 77; AB802

[36] Except for gas savings at dual fuel utilities for the following building types: office, retail, school, and health.

ensure that reasonable savings were expected from each end use. Costs were applied to these energy savings using an average UES ($/kWh or $/therm) associated with each end use across the 2013-2015 California EE portfolio.

For the 2019 Study, the team also examined reports from PG&E's Commercial Whole Building Program. Navigant could not calculate an expected savings value from the reports due to the large variability in savings and the small sample size, but concluded that saving 15% of consumption at the whole building level is realistic as it fell within the range of the PG&E study results.

The data sources listed in Table 3-17. were used for this analysis.

**Table 3-17. Commercial Retrofit Whole Building Data Sources**

| Data Items | Data Sources |
|---|---|
| Energy Intensity by End Use and Building Type | CEC, California Commercial End-Use Survey, March 2006 |
| Floorspace | CEC, 2016 IEPR |
| Costs | CPUC, California EEStats, 2013-2015 Program Cycle |

#### *3.3.2.2 Residential*

Table 3-18. provides the sources of data used in characterizing the Energy Upgrade California program. Costs were applied to the energy savings using an average UES ($/kWh or $/therm) as derived from the program metrics reported by all Energy Upgrade California IOU programs. The 2020 results indicate lower savings than the 2017 Study due to low realization rates in the more recent evaluation report.

**Table 3-18. Residential Retrofit Whole Building Data Updates**

| Data Items | Data Sources |
|---|---|
| Savings | DNV GL, Final Report: *2015 Home Upgrade Program Impact Evaluation*, June 23, 2017, CALMAC ID: CPU0162.01 http://www.calmac.org/publications/RES_5.1_HUP_FINAL_REPORT_ATR_06-30-17.pdf |
| Costs | CPUC, California EEStats, 2013-2015 Program Cycle |

## 3.4 Agriculture, Industrial, Mining, and Street Lighting Technology Characterization

The 2019 Study updated the AIMS sectors, with a heavy focus on the agriculture and industrial sectors and limited focus on the mining and street lighting sectors. The Navigant team's approach to each sector's data sources varied. The primary effort for agriculture and industrial focused on historical program data to directly relate measures developed for the PG Model to IOU program activities. The data approaches to mining and street lighting remain largely consistent with the 2015 Study, but the Navigant team reviewed and updated the existing data with new and current sources in 2018, with no update for the 2019 Study.

The following sections provide additional details about the development of data for the four AIMS sectors. Additional detail on the industrial and agriculture sectors and measures can be found in Appendix D.

This section and material in Appendix D represent use of best available data. Navigant notes that the existing datasets for AIMS sectors have data gaps and are not necessarily California-specific. Navigant has conducted similar industrial potential analysis in other jurisdictions[37] and, in all cases, the savings estimates are lower than expected for several reasons: (a) there is no good baseline or saturation data for industry; (b) assumptions are made regarding costs; and (c) many studies leverage the Industrial Assessment Center (IAC) database[38] - to various levels. To support better data for future studies, Navigant suggests a review of the following characteristics for the AIMS sector:

- Conduct market characterization studies to define the end use breakdown
- Conduct measure characterization to support saturation data and cost estimates
- Review of industry standard practices to understand impacts regarding natural adoption
- Address concerns related to program participation and if policies prohibit further program participation. It is important to review if projects are stalled or reduced in scope when denied rebates.

### *3.4.1 Agriculture and Industrial Sectors*

Navigant identified over 2,000 records[39] in the 2016 to Q3 2017 EEStats data associated with the agriculture and industrial sectors. The team refined this list of records, focusing on the high impact measures (i.e., those contributing significant amounts of energy savings) and excluded records with negligible savings contributions or those representing niche activities. Navigant then combined similar ProgramIDs into representative technology groupings based on the team's familiarity with the industrial market.

During the 2017 Study, the Navigant team presented the list of initial representative technologies to stakeholders, seeking feedback on whether the list appropriately represented the two sectors and whether to add or delete any of the identified technologies. Stakeholders generally agreed with the overall approach to leveraging EEStats data. For the 2019 Study, the team continued to leverage the EEStats approach. The final technology list is broken into four categories and summarized in Table 3-19:

- Discrete **identified deemed** measures referred to as **characterized custom**, readily defined and forecast using the Bass diffusion model and custom savings estimates.
- **Generic custom** measures included in projects unique to various subsectors that cannot be readily defined at the measure level or forecast using a Bass diffusion model. Navigant describes the methodology used to characterize these generic custom measures in Section 3.5. Study measures that were marked as other or contributed up to 20% of the characterized custom list were included in this category.

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[37] One example is the study for Energy Efficiency Alberta, https://www.efficiencyalberta.ca/potentialstudy

[38] https://iac.university/#database

[39] Navigant defined a record as an EEStats program identification or ProgramID field—e.g., PGE21021 and measure group. combination.

- **Emerging technologies** measures are considered nascent or emerging technologies and cannot be readily defined at the measure level or forecast using a Bass diffusion model. Navigant describes the methodology used to characterize these generic custom measures in Section 3.5.
- **BROs or SEM** measures that include retrocommissioning (RCx) and some optimization. This measure is modeled with the BROs measures and cannot readily be forecast using a diffusion model as described in Section 2.1.1.

**Table 3-19. AIMS Modeling Methodology**

| Categories | Model Approach | Applicability |
|---|---|---|
| **Emerging Technologies** | Top-down approach | Ag and Ind |
| **BROS*** | Top-down approach | Ag and Ind |
| **Characterized Custom**** | Bottom-up Bass diffusion approach | Ag, Ind, Street Lighting, and Mining |
| **Generic Custom** | Top-down approach | Ag and Ind |

* SEM is modeled as the AIMS BROs measure by allocating the historical RCx as a proxy for SEM savings.
** Mining and street lighting only have characterized custom.

### *3.4.1.1 Agricultural and Industrial Characterized Custom*

For the 2019 Study, the Navigant team characterized 17 technology groups for the agriculture sector and 14 for the industrial sector, representing the characterized custom measures for the diffusion model. These are sourced from the EEStats technologies. The industrial and agriculture sectors of this 2019 Study are informed by 122 unique measure groups sourced from EEStats. This approach provided consistency with the methods used in the residential and commercial sectors and allowed the modeling team to calibrate the PG Model using prior program achievements detailed in EEStats and establish greater confidence in the results.

### *3.4.1.2 Technology Characterization*

The PG Model required characterizing technology-level inputs including UES, unit costs, and the saturation or density of efficient versions of each technology existing in the marketplace. The team mined data sources to complete a comprehensive characterization of the agriculture and industrial technologies.

- **Agricultural** data sources for measure characterization included EEStats, CPUC workpapers, and data provided by the IOUs. The team also relied on DEER for information on energy savings estimates by technology.
- **Industrial** data sources were similar to those mined for the agriculture sector, including EEStats and data provided by IOUs, the CPUC, and the CEC. For energy savings estimates, the team used the Industrial Assessment Center (IAC).[40]

[40] https://energy.gov/eere/amo/industrial-assessment-centers-iacs

The team then weighted the results of each source and rolled them up to estimate the technology-level inputs. For most of the measures, Navigant leveraged California-specific resources, but when not applicable or available to certain measure types, the team used other peer group jurisdictions and substituted in California-specific variables where possible.[41]

***Energy savings.*** The Navigant team used data from the national IAC database to supplement EEStats data and inform the energy savings estimates for the industrial diffusion technologies. The IAC network consists of 24 universities that have completed over 16,000 industrial assessments at industrial facilities across the nation. Each assessment completed by the IAC includes detailed recommendations for improving energy consumption at a given site,[42] the specific energy savings the site can expect by implementing such improvements, and the total energy each site currently uses. Navigant notes that the PG Model study efforts have relied on IAC data since 2011.

Navigant mapped all the unique IAC recommendations to the list of characterized custom industrial technologies created from the EEStats database. The team then used NAICS coding to sum the energy savings estimates for each technology to the entire industrial sector by building type and divided it by the total energy consumption for all buildings of that type. This provided the percentage each technology saves by building type across the entire industrial sector.[43] The team followed this process for both electric (kWh) and gas (therm) consuming industrial measures.

The IAC database included robust, informative data for all but one industrial technology. The technology not included in the IAC but identified in EEStats is wastewater aerators. Wastewater aerators are listed as energy efficient aerators in the technology list and leverages an SCE workpaper for data.

***Costs.*** Navigant primarily used the EEStats database to calculate the incremental cost per UES for technologies included in the industrial and agriculture analysis.[44] The team compared the 2016-Q3 2017 data with the previous 2017 Study to ensure the costs aligned since measure costs can be variable year over year and from project to project. The team multiplied the incremental cost per unit by the technology energy savings to estimate technology costs.

***EUL and NTG.*** Navigant used the EEStats database to calculate the EUL and NTG ratios for all technologies included in the industrial technology list. The team compared this calculation across industrial and agricultural findings and the 2017 Study. Adjustments were made as necessary.

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[41] Other sources include the Pennsylvania TRM (http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx); the Illinois TRM (http://www.ilsag.info/technical-reference-manual.html); the Michigan Energy Measures Database (http://www.michigan.gov/mpsc/0,4639,7-159-52495_55129---,00.html); and the Wisconsin TRM (http://dsmexplorer.esource.com/documents/Wisconsin%20-%2010.22.2015%20-%202016%20TRM.pdf). See the Agriculture MICS for more detail on which measures these sources informed.

[42] The IAC recommendations cover upgrades to inefficient equipment, the addition of energy-reducing technologies to existing equipment, and improvements to industrial processes through controls.

[43] The final percentages of savings by building type are a nationwide value. The IAC data does not contain enough assessment data points to calculate these values on a state or region level with any degree of statistical confidence. Further, Navigant's vetting of IAC data during previous PG study efforts determined that national-level IAC data is representative of California industrial sector activities.

[44] The costs in EEStats include labor to represent the full incremental cost of implementation. The lighting end use relied on a cost per kWh consumed rather than cost per kWh saved because the team relied on commercial data for the industrial lighting end use measures.

***Saturations and Densities.*** Technology characterization requires data on the saturation of efficient technologies currently existing in the industrial marketplace. This provides a clearer picture of how much potential energy savings still exists by upgrading remaining baseline technologies within that marketplace. For industrial technologies analyzed using the IAC database, the team assumed that every recommendation made at an industrial facility meant that this facility still had the inefficient baseline technology installed. For example, if a facility received a recommendation to upgrade its lighting system, the team assumed that this facility still used inefficient or baseline lighting technologies. This assumption allowed the team to identify the percentage of sites with baseline equipment (i.e., those receiving a recommendation for a technology).[45] The team then used this baseline percentage as one of the variables for calculating the total sector savings available for each measure defined in the Energy Savings section above.

For measures not covered in the IAC database, the team used professional judgement based on data sources such as commercial sector saturation data and feedback from stakeholders to estimate a density of efficient versus inefficient technology.

### *3.4.2 Mining Sector*

The 2019 Study approach and data inputs are unchanged from the 2017 Study. The Navigant team defined the mining sector inputs using a bottom-up approach consistent with the other AIMS sectors. The team sourced data from several sources including region-specific information on oil and gas extraction activities from the California Department of Conservation.[46] This data provided the number of active and idle wells, the amount of oil and water produced from wells, the amount of steam and hot water generated for mining operations, and the number new wells created.[47]

The Navigant team also used consumption data from the CPUC and other secondary sources, including IOU program data and industry-specific reports and studies. These sources inform estimates for energy savings, costs, EUL, and NTG. Navigant also updated select model inputs such as equipment stocks, sector consumption, and efficient equipment saturations.

### *3.4.3 Street Lighting Sector*

Like the mining sector, the PG Model and the updates for the 2018 street lighting effort rely on the inputs established in previous studies.[48] The team also used a bottom-up approach to define sector inputs. Information provided directly by the IOUs served as the primary basis for street lighting inputs, specifically the inventories of customer-owned and IOU-owned street lights included in the LS-1 and LS-2 rate classes.[49] The PG Model outputs reflect potential energy savings associated only with customer-owned

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[45] The IAC recommendations do not provide a density of efficient equipment in the marketplace because the inverse of the assumption regarding recommendations is not true (i.e., just because an industrial facility did not receive a recommendation does not mean it already had the efficient version of the recommendation installed).

[46] http://www.conservation.ca.gov/dog

[47] http://www.conservation.ca.gov/dog/pubs_stats/annual_reports/Pages/annual_reports.aspx

[48] http://www.cpuc.ca.gov/General.aspx?id=2013

[49] Example from SCE: https://www.sce.com/NR/sc3/tm2/pdf/ce37-12.pdf

 

lamps (LS-2 rate schedule). However, Navigant gathered data on IOU-owned lamps (LS-1 rate schedule) to aid with data vetting and quality control as well as initial saturation levels.

The IOU street lighting inventories inform several model inputs including equipment stocks, densities, and efficient equipment saturations. The Navigant team also relied on secondary sources to update equipment costs. The team revised cost forecasts for LEDs with information from the DOE's Solid-State Lighting program.[50]

This study includes an update on the initial saturation of street lights per the IOU data of installed street lighting. Additionally, the team indicated that LED becomes standard practice baseline in 2019. As a result, savings from LED lamps do not appear in the forecast period and only one measure remains for this sector: advanced lighting controls.

## 3.5 Industrial and Agriculture Custom Technologies Data Sources

Generic custom measures in the industrial and agriculture market sectors are projects that tend to be specific to an industry segment or production method. Generic custom measures are often listed by non-descript names such as Process-Other in publicly reported IOU tracking data,[51] and they present several challenges within a potential forecast:

- Having unique attributes that make them difficult to forecast within the diffusion-based PG Model
- Being unlikely to saturate over time due to continual process changes in the industrial and agricultural sectors
- Often consisting of emerging technologies that are in the early adoption phase, with little to no engineering details, market parameters, or workpapers

As discussed further in Appendix F, for the 2019 Study the definition of generic custom measures was revised from the 2017 Study to account for the following:

- A large number of measures that are defined but where any one measure contributes only a small percentage of portfolio savings (e.g., faucet aerator or HVAC controls) are now included in the generic custom measure class.
- The 2019 model separated out RCx savings from generic custom savings and considered RCx to be part of SEM savings.
- The agricultural sector forecast is also affected because the definition of which NAICS codes are to be included in the agricultural sector was redefined for the 2019 model to better align with the IEPR agricultural sector definition.

The 2019 model treats generic custom measures as a specific measure class. Table 3-20. provides the inputs for electricity and natural gas for these measures, and additional discussion follows the table. Navigant provides separate UES estimates for the industrial and agricultural market sectors. The team calculated the EUL for these measures at 15 years since most savings come from larger capital

[50] 2014 report: https://energy.gov/sites/prod/files/2015/05/f22/energysavingsforecast14.pdf; 2016 report: https://energy.gov/sites/prod/files/2016/10/f33/energysavingsforecast16_0.pdf

[51] Generic custom also includes a large number of discrete measures that each contribute a small amount of savings and collectively account for less than ~10% of sector savings.

investments with long operating lives. Appendix F provides additional details on the generic custom analysis and forecast methodology.

**Table 3-20. Generic Custom Measures – Key Assumptions**

| Sector | Type | EUL Years | Savings Range | | Cost | | kW/kWh Savings Ratio |
|---|---|---|---|---|---|---|---|
| | | | kWh | therm | kWh | therm | |
| AIMS | Generic Custom | 15 | 0.08% (Ind)<br>0.20% (Ag) | 0.12% (Ind)<br>0.9% (Ag) | $0.33 | $2.25 | 0.0002 |

The Navigant team estimated savings based on building type consumption (kWh or therms/year); however, since these technologies are forecast as a single class of measure, savings do not vary by market segment or IOU. Navigant based generic custom savings in the 2019 Study on an analysis of data available through the California EEStats portal[52] for programs operating from 2013 through 2017. Data for these program years provided the level of detail necessary to separate generic custom measures from RCx and other custom measures that could be defined and modeled using a Bass diffusion approach. Table 3-21. summarizes the generic custom savings contribution to the overall sector when accounting for the removal of RCx from generic custom and the addition of the large number of smaller measures now considered part of the generic custom measure class.

**Table 3-21. Generic Custom Contribution as a Percentage of Sector Savings**

| Sector | Electricity | Gas |
|---|---|---|
| Industrial | 22% | 49% |
| Agricultural | 35% | 41% |

Based on this analysis and sector-level consumption forecasts provided by the CEC, Navigant determined that generic custom measures would save roughly 0.08% and 0.12% of annual industrial sector electricity and natural gas usage, respectively. Using a similar methodology, Navigant forecast savings from generic custom measures in the agricultural sector at 0.20% of annual electricity consumption and 0.09% of annual gas usage. These percentages are used in both the reference or aggressive cases and remain constant throughout the forecast horizon.

Navigant based costs for electricity and natural gas savings on an analysis of industrial and agricultural programs operating in California and across the nation throughout 2016, which did not vary significantly through 2017. They are estimated at $0.33/kWh and $2.25/therm and are applied consistently across sectors and utilities throughout the 2019 Study forecast horizon.

Applicability and penetration rate are key inputs to the savings forecast. Applicability of generic customer measures in the industrial and agricultural sectors is 100% because these measures are considered ubiquitous to all activities in all market segments. The approach to forecasting the penetration rate for generic custom measures changed for the 2019 Study. In the 2017 Study (and prior years), penetration rates were held constant over the forecast horizon under the assumption that industrial facilities continually upgrade equipment and processes and, therefore, generic custom measures would be

[52] http://eestats.cpuc.ca.gov/Default.aspx

installed at the same rate as past program activity. Based on an analysis of EEStats data from 2013 through 2017, it was determined that generic custom savings are decreasing over time after separating out the contribution from RCx. As such, the penetration rate for generic custom was revised to show an annual decrease of approximately 3.3% for both electricity and gas.

### *3.5.1 Emerging AIMS Technologies*

New emerging technologies to reduce energy use and energy demand are continually being introduced in the California marketplace. The 2019 Study is an update to the approach used for the 2017 Study. For the 2017 Study, the Navigant team identified approximately 1,100 potential emerging technologies. These emerging technologies were run through a screening process to rate energy technical potential, energy market potential, market risk, technical risk, and utility ability to impact market adoption. This process yielded 169 emerging technology processes[53] for final consideration within the model. For the 2019 Study, the team reviewed the data sources used in the 2017 Study to include measures that might have been added since the initial review and updated measures originally identified for which there might be more recent data. For a summary of the emerging technology literature reviewed and details on the screening process and how it was used to define subsector potential, see Appendix F.

Table 3-22. summarizes the resulting savings and cost factors; additional discussion follows the table. Navigant applied segment-specific electric and gas savings, as well as costs, EUL, and the kW/kWh savings ratio consistently across all utilities.

**Table 3-22. Emerging Technologies – Key Assumptions**

| Sector | Type | EUL Years | Savings Range (Percentage of Building Energy Consumption) | | Cost | | kW/kWh Savings Ratio |
|---|---|---|---|---|---|---|---|
| | | | kWh | therm | kWh | therm | |
| AIMS | Emerging Technologies | 10 | 0.93% - 9.62% | 0.0% - 14.21% | $0.42 | $2.83 | 0.000195 |

The model uses a universal EUL of 10 years to accommodate the broad range of emerging technology adoption curves. Similarly, a universal 0.000195 ratio of kW to kWh was applied to all three electric utilities. This is the same value used for SEM, and it is based on an analysis of several third-party SEM programs operating in California during the 2014-2015 portfolio cycle. Actual emerging technology-specific EULs and kW/kWh are presently unknown and can be refined during future emerging technologies market studies as additional information becomes available.

The Navigant team estimated costs for electricity and natural gas emerging technologies savings based on an analysis of industrial and agricultural programs operating throughout 2016. Costs for electricity and natural gas savings are estimated at $0.42/kWh and $2.83/therm and are applied consistently for all utilities and across all industrial and agricultural sectors. Additional information on the methodology used to derives UES values and costs for emerging technologies measures can be found in Appendix F.

In determining applicability, emerging technologies apply to different industrial and agricultural sectors in varying degrees, and the Navigant team assessed segment-specific technology applicability during the

[53] The emerging technologies represent a process for reducing energy consumption and not necessarily a specific technology.

screening process. For emerging technologies that were determined to be feasible at the segment level, a UES estimate was completed for each emerging technology that includes adjustment for applicability. As such, the team assigned each sector a 100% applicability in the forecast model with the understanding that applicability was considered during the screening process and is embedded in the UES value for each emerging technology.

Adoption of future emerging technologies will vary by technology. Some emerging technologies will gain widespread customer acceptance and capture broad market share based on price, energy savings, and other customer-driven factors, while other emerging technologies will see a more limited adoption. Although the team assigned unique risk factors to each new technology during the screening process, it is impossible to definitively predetermine which technology will be successful. Therefore, the model considers all emerging technologies in aggregate and applies a consistent participation rate to all emerging technologies. As such, penetration forecasts for both the industrial and agricultural sectors begin with a saturation level of 0.1% for the reference case and follow a compound annual growth rate of 3.25%, yielding a target saturation of 8.6% by 2030. The 2030 target saturation of the portfolio of AIMS-relevant emerging technologies is an estimate that acknowledges the timeline over which new technologies move through the adoption cycle to reach 80% saturation (typically ranging from 10 to 30 years), and the relatively slow turnover of the diverse set of production equipment associated with many industrial processes.

## 3.6 Codes and Standards

C&S modeled in the PG study use data from multiple sources. For evaluated C&S, the study uses ISSM[54] as its data source. For unevaluated C&S, the study uses data provided by California IOUs via a formal data request.[55] For all other future C&S, the study uses additional data and information provided by the CEC along with additional assumptions made by the Navigant team.

Table 3-23. lists the number and type of C&S and their data source. A full list of the modeled C&S, their compliance rates, effective dates, and policy status (on the books, possible, or expected)[56] are listed in Appendix E. Of special note is the pending 2020 federal standard on the expanded scope of general service lamps (GSLs - Expanded Scope). Although the IOUs provided this as a claimed standard starting in the year 2020, the stated intent by the federal government to roll back this standard as well as the uncertainty in possible legal challenges makes the savings uncertain. For this reason, the GSL - Expanded Scope standard is listed as “Possible” and therefore does not contribute to C&S savings reported in this study. However, the model can produce a forecast of savings from “Possible” C&S for use by the California Energy Commission in its analysis of Additional Achievable Energy Efficiency.

[54] Cadmus and DNV GL. *Integrated Standards Savings Model (ISSM).* 2017.

[55] PG&E, SCE, SDG&E, and SCG all responded to the data request on February 4, 2019.

[56] **On the books:** A code or standard that has been passed into law.
**Expected:** A code or standard that is in development.
**Possible:** A code or standard that is not actively being developed, but other policy guidance suggests these should be the next logical C&S to be developed. Possible C&S are not included in the forecasted results of the PG study, but are made available for the California Energy Commission’s Additional Achievable Energy Efficiency forecasting process.

**Table 3-23. C&S Data Source Summary**

| IOU C&S Group | Number and Type of Codes and Standards | Data Source |
|---|---|---|
| 2005 Title 20 | 22 appliance standards | ISSM |
| 2006-2009 Title 20 | 13 appliance standards | ISSM |
| 2011 Title 20 | 4 appliance standards | ISSM |
| Unevaluated Title 20 | 20 appliance standards | IOU data request |
| Future Title 20 | 6 appliance standards | CEC input and Navigant team estimates |
| Evaluated Federal | 26 appliance standards | ISSM |
| Unevaluated Federal | 14 appliance standards | IOU data request |
| Future Federal | 12 appliance standards | CEC input and Navigant team estimates |
| 2005 Title 24 | 19 building codes | ISSM |
| 2008 Title 24 | 22 building codes | ISSM |
| 2013 Title 24 | 46 building codes | ISSM |
| 2016 Title 24 | 12 building codes | IOU data request |
| 2019 Title 24 | 40 building codes | IOU data request |
| 2022-2029 Title 24 | 6 building codes | CEC input and Navigant team estimates |

*Sources: Cadmus and DNV GL. ISSM. 2017.; IOU data request; California Energy Commission*

The 2017 Study made several adjustments to the data obtained:

- An uncertainty factor of 80% was applied to all unevaluated C&S.
- Per guidance from Cadmus (the previous C&S evaluator), several 2013 Title 24 codes were removed from the analysis because their savings were already included in Whole Building codes.[57]

For 2013 Title 24, ISSM provides the option to use either bounded or unbounded energy savings adjustment factors (ESAF), which are analogous to compliance factors for appliance standards.[58] Unbounded refers to the case where a building, project, or measure can consume less energy than the level established by the current Title 24 code, resulting in an ESAF greater than 100%. Bounded refers to limiting the ESAF values to a maximum of 100%. The 2017 Study uses bounded values from the ISSM.

The 2019 Study determined new energy savings estimates for future Title 24 codes beyond the 2019 vintage including the 2022, 2025, and 2028 cycles for the commercial sector.[59] Personal communication

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[57] Cadmus and DNV GL. California Statewide Codes and Standards Program Impact Evaluation Phase Two, Volume Two: 2013 Title 24. August 2017.

[58] Cadmus and DNV GL. California Statewide Codes and Standards Program Impact Evaluation Phase Two, Volume Two: 2013 Title 24. August 2017.

[59] The future Title 24 codes were not considered in the 2017 Study forecast due to the highly uncertain nature of their savings. The Navigant team notes that these future savings are still highly uncertain. While California has a goal of all new commercial construction to be ZNE by 2030, the regulatory path toward requiring this by 2030 is uncertain.

with staff at the CEC provided insight on the path between 2019 Title 24 and 2028 Title 24, as illustrated Table 3-24..

**Table 3-24. Progression of Commercial T24**

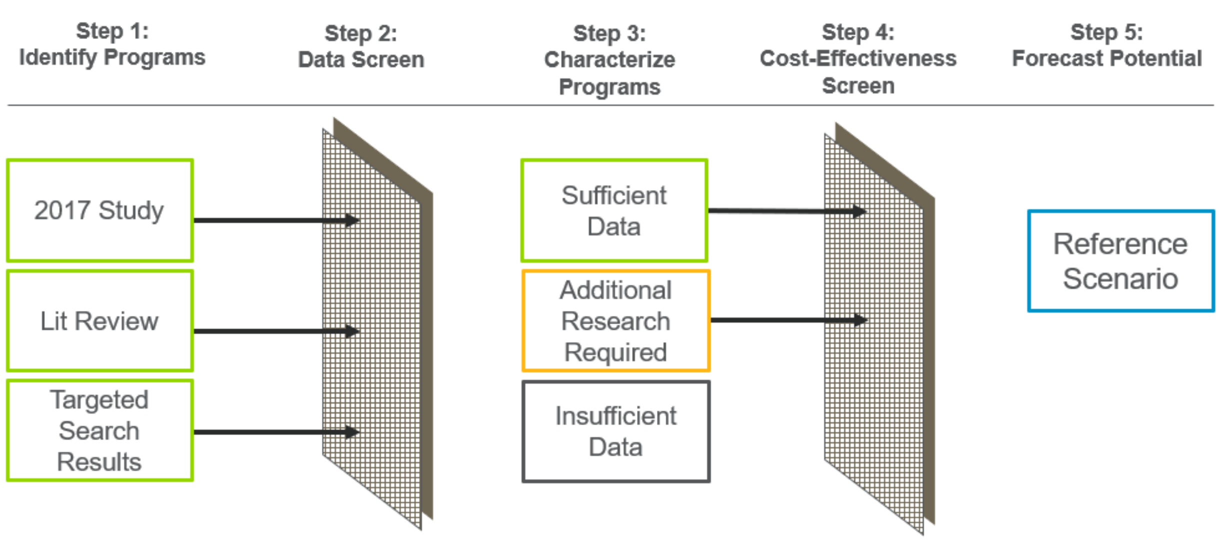
| Title 24 Code Cycle | Cumulative Percentage of 2028 Savings Target | Incremental Savings toward 2028 Target |
|---|---|---|
| **2016** | 0% | - |
| **2019** | 33% | 33% |
| **2022** | 50% | 17% |
| **2025** | 67% | 17% |
| **2028** | 100% | 33% |

Navigant scaled 2019 Title 24 claimed savings based on the last column in Table 3-24. to develop estimates of savings for the 2022-2028 Title 24. NOMAD factors for 2022-2028 Title 24 were adapted from 2019 Title 24 and time-shifted to an appropriate start date.

## 3.7 BROs Energy Efficiency

To forecast customer behavioral energy savings, the Navigant team considered a wide range of behavioral intervention types for both residential and commercial customers. Because this is an uncertain area that has been getting a lot of interest from the industry and was called out in AB802 and SB350 as an emerging area for increased opportunities given NMEC, the team cast the net wide in consideration of interventions. Figure 3-3 illustrates the five-step selection process used to determine intervention types to include in the reference case scenario.

**Figure 3-3. Selection Process for Residential and Commercial BROs EE Programs**




**Step 1: Identify programs.** The first step was to identify general program categories and then to conduct a literature review to identify specific programs. The team augmented its existing knowledge base drawn

from the 2017 Study with additional findings from numerous evaluations and research studies, as well as findings from the Consortium for Energy Efficiency Database, American Council for an Energy-Efficient Economy, and various other secondary research sources. Once appropriate utility programs had been identified, the team sought out formal evaluation findings wherever possible—particularly evaluations of programs run the California IOUs—as well as other commissioned original research studies.

**Step 2: Screen data.** Potential programs were then organized by intervention type and screened to ensure sufficient data. This initial literature review captured all available data, including utility, program name, state, number of years, number of participants per year, participant type, participation rates, eligibility considerations, energy savings, persistence, and cost. Because findings were obtained from many sources, data was inconsistently reported and thus apples-to-apples comparisons were not always possible.

**Step 3: Characterize interventions.** Behavioral interventions were ultimately included in the model when a sufficiency of data was available for five primary modeling inputs:

- kWh savings
- therm savings
- Participation rates
- Persistence
- Cost

While savings and participation rates were generally readily available from formal EM&V evaluations, cost data was more often scarce. So, in some cases, the team extrapolated or estimated based on a limited number of data points.

The Navigant team calculated penetration rates based on relevant EM&V-reported program participation rates for current California IOU program offerings and reported participation in programs in other states.

The team modeled an EUL of 1 year for residential programs. Commercial programs used a 2- or 3-year EUL per CPUC Decision 16-08-019, unless evidence supported a longer duration.

Specific modeling inputs for each intervention type are discussed in detail in Appendix C.

**Step 4. Cost-effectiveness screen.** The C-E screen used the TRC test and the latest CPUC-approved avoided costs for each utility. This screen was used to inform the team if measures should be removed from the reference case. Even programs that were not cost-effective are included in the aggressive scenario as an indication of the data available on the potential of these programs.

**Step 5. Forecast potential.** The forecasts are the result of professional judgement based on program operations and whether participation is utility driven (opt out) or customer driven (opt in). The forecast penetration rates were adjusted to represent a reference scenario and an aggressive scenario.

Many intervention types were characterized to forecast potential. A more detailed description of each of the final intervention types follows in Table 3-25.; additional details can be found in Appendix C.

**Table 3-25. Behavioral Intervention Summary Table**

| Sector | Type of Behavioral Intervention | Brief Description | EUL (Years) |
|---|---|---|---|
| RES | HERs | Residential customers are periodically mailed HERs that provide feedback about their home's energy use, including normative comparisons to similar neighbors, tips for improving EE, and occasionally messaging about rewards or incentives. | 1 |
| RES | Web-Based Real-Time Feedback | Real-time information and feedback about household energy use provided via websites or mobile apps. | 1 |
| RES | In-Home Display Real-Time Feedback | Real-time information and feedback about household energy use provided via energy monitoring and feedback devices installed in customer homes. | 1 |
| RES | Small Residential Competitions | Small residential competitions are organized competitions with fewer than 10,000 participants per year in which participants compete in events, contests, or challenges to achieve a specific objective or the highest rank compared with other individuals or groups as they try to reach goals by reducing energy consumption. | 1 |
| RES | Large Residential Competitions | Large residential competitions are organized competitions with more than 10,000 participants per year in which participants compete in events, contests, or challenges to achieve a specific objective or the highest rank compared with other individuals or groups as they try to reach goals by reducing energy consumption. | 1 |
| RES | Universal Audit Tool | The Universal Audit Tool (UAT) is an opt-in online tool that asks residential customers questions about their homes, their use of household appliances, and occupancy patterns and then it offers EE advice regarding ways they can save money and energy. | 1 |
| COM | Commercial Competitions | Commercial competitions are organized competitions between cities, businesses, or tenants in multi-unit buildings in which participants compete in events, contests, or challenges to achieve a specific objective or the highest rank compared with other groups as they try to reach goals by reducing energy consumption. | 2 |
| COM | Business Energy Reports (BERs) | BERS are periodically mailed to small and medium size businesses to provide feedback about their energy use, including normative comparisons to similar businesses, tips for improving EE, and occasionally messaging about rewards or incentives. | 2 |
| COM | Building Benchmarking | Building benchmarking scores a business customer's facility or plant and compares it to other peer facilities based on energy consumption. It also often includes goal setting and rewards in the form of recognition. [60] | 2 |

[60] Stakeholders informally commented that building benchmarking may not be claimable by IOU programs given benchmarking is required by AB802. However, no data/policy was cited as definitively disallowing IOUs from claiming savings from benchmarking programs. Furthermore, there may be potential for building benchmarking savings from segments of the commercial building stock not included in the AB802 mandate. Therefore, the Navigant team continues to include it in the potential forecast for this report within the Aggressive BROs scenario.

| Sector | Type of Behavioral Intervention | Brief Description | EUL (Years) |
|---|---|---|---|
| COM/IND/ AG | Strategic Energy Management (SEM) | SEM is a long-term continuous improvement process that educates and trains business energy users to develop and execute long-term energy goal setting and strategic planning and to integrate energy management into business practices throughout the organization—from the corporate board office to the boiler room and the work floor. It can include consulting services, customized training, benchmarking and measurement, feedback, data analysis, and performance review. | 5 |
| COM | Building Energy Information Management Systems (BEIMS) | BEIMS enable building operations staff to achieve significant energy savings by monitoring, analyzing, and controlling building system performance and energy use. BEIMS can include benchmarking and utility bill tracking software, energy information systems (EIS), building automation systems, fault detection and diagnostic tools, and automated system optimization software, as well as value-added services and contracts. | 3 |
| COM | Building Operator Certification | Building operator certification trains and educates commercial building operators about how to save energy by encouraging them to adopt energy efficient behaviors and make building changes that reduce energy use. | 3 |
| COM | Retrocommissioning | Commissioning is a whole building systems approach to improving an existing building's performance by identifying and implementing operational improvements to save energy and increase comfort. Retrocommissioning refers to commissioning a building that has not previously been commissioned. This program also includes recommissioning, or commissioning a building that has been commissioned at least 5 years prior. | 3 |

### *3.7.1 Data Rigor*

Navigant conducted an extensive industry scan for data on BROs initiatives and found that many of these programs are relatively new and much learning about their effectiveness is ongoing. The published data spans a wide range in the rigor of analysis conducted on the data around energy savings resulting from these interventions. Table 3-26. provides a snapshot of the quality of data collected for this study. Across the board, demand savings data is often limited and cost data is hard to obtain. Penetration forecasts are the most uncertain because of limited historic penetration rates upon which to base a forecast.

The Navigant team recommends the industry consider pilot studies along with measurement and verification to provide better data to future potential studies. Interventions that literature claims to show large promise though limited verified data exists include prepay programs, SEM, building benchmarking, competitions, web-based feedback, and in-home real-time feedback.

### Table 3-26. Qualitative Assessment of Data Quality

| Sector | Program | Savings | | | Cost | Applicability | Participation Rate | Penetration Forecast | Data Updates |
|---|---|---|---|---|---|---|---|---|---|
| | | kWh | therms | kW | | | | | |
| Residential | Audits [1] | ● | ● | ● | ◌ | ● | ● | ● | ✓ |
| Residential | Home Energy Reports | ● | ● | ● | ● | ● | ● | ● | ✓ |
| Residential | In Home Display RT Feedback | ○ | ○ | ◌ | ○ | ● | ◌ | ◌ | |
| Residential | Web-Based Real-Time Feedback | ○ | ○ | ◌ | ● | ● | ● | ● | |
| Residential | Small Residential Competitions | ○ | ○ | ◌ | ○ | ● | ○ | ◌ | |
| Residential | Large Residential Competitions | ● | ● | ◌ | ○ | ● | ● | ◌ | |
| Commercial | Building Operator Certification | ● | ● | ◌ | ◌ | ● | ◌ | ◌ | |
| Commercial | Business Energy Reports | ● | ● | ◌ | ◌ | ● | ◌ | ◌ | |
| Commercial | BEIMS | ● | ● | ● | ◌ | ● | ● | ◌ | ✓ |
| Commercial | Commercial Competitions | ● | ● | ◌ | ○ | ◌ | ● | ◌ | |
| Commercial | Strategic Energy Management | ○ | ◌ | ◌ | ◌ | ● | ◌ | ◌ | ✓ |
| Commercial | Building Benchmarking | ○ | ○ | ◌ | ● | ● | ◌ | ◌ | ✓ |
| Commercial | Retrocommissioning | ● | ● | ● | ◌ | ● | ● | ◌ | ✓ |

| Legend | |
|---|---|
| ● | California program data and its derivatives |
| ○ | Aggregated reports and non-verified savings reported by utilities outside of California |
| ◌ | Assumed equivalence to similar programs or other forms of professional judgment |
| ✓ | Indicates that inputs for this program have new data available since the 2018 Potential and Goals Study |
| NA | The majority of prepay programs reviewed were electric programs. While some gas programs exist, savings were excluded due to data insufficiency. |

[1] Program is newly added in the 2020 Potential & Goals Study.

# 4. 2019 STUDY RESULTS

The results of past potential studies have been used by policymakers as a technical foundation to set savings goals for the next regulatory cycle. The 2019 Study is the foundational basis for the CPUC's 2020 and beyond EE goal setting process. Table 4-1 provides a summary of key findings from this study and the potential implications of each finding.

**Table 4-1. 2019 Study Key Findings and Implications**

| Key Finding | Implication |
|---|---|
| **1. Savings for lighting measures are substantially reduced relative to the 2017 Study.** | IOUs should identify additional non-residential lighting opportunities and maintain their program offerings to harvest the remaining savings potential through accelerated replacement programs. IOUs should ensure C&S savings claims properly quantify for savings due to LED baseline policy. |
| **2. Gas savings are substantially reduced relative to the 2017 Study.** | Despite decreases, the study still shows gas EE potential which will enable California to progress toward its statewide decarbonization goals. |
| **3. Higher TRC benefit-cost thresholds reduce overall savings potential.** | Based on scenario results, maintaining a 1.0 TRC cutoff at the measure-level results in an overall cost-effective portfolio, suggesting that it is not necessary for the CPUC to set the highest cutoff. |
| **4. The combined effect of various EE policies limits the overall market potential.** | IOUs and program administrators should broaden their program designs to target as many savings opportunities highlighted in this study as possible. |
| **5. This study identifies new measures that have limited proven experience in the marketplace.** | The industry should roll out pilots and demonstrations to expand the available data and better inform future programs that highlight emerging interventions. |
| **6. The savings potential from C&S measures represents a significant portion of the potential highlighted in this study.** | The industry should continue and enhance the evaluation of C&S advocacy efforts to ensure accuracy of savings forecasts and support the development of new C&S. |
| **7. Adjustments to non-financial factors such as consumer awareness and education appear to lead to larger savings potential.** | IOUs and program administrators should consider revamping their marketing and outreach efforts to target pockets of savings potential not previously considered. |
| **8. Industrial sector shows a decreasing sector savings potential trend.** | Improved market and measure characteristics and saturation data would minimize the need to forecast heavily leveraging historical data and may uncover additional opportunities for savings. |

## 4.1 Incentive Program Savings

The following subsections summarize statewide market potential results. These results are for all IOUs combined. The IOU breakdown for these savings can be found in the results viewer that accompanies this report (see Section 4.3 for details). All results are presented as net savings; all statewide results are inclusive of interactive effects. Note that the purpose of this report is to present the findings of the Navigant team's potential study and not to establish goals—that is under the purview of the CPUC. As such, the scenario comparisons presented in the following subsection are meant to illustrate a range of potential that can be achieved based on the team's study.

Figures in this section focus on electric and gas savings. Peak demand savings are not illustrated, though they are quantified by the model. Full results for all scenarios and all utilities are available in the results viewer (discussed further in Section 4.3).

### *4.1.1 Total Savings and Spending by Scenario*

Table 4-2. through Table 4-4 show the total incremental market potential from all savings sources by scenario. A few important notes about these results:

- Equipment rebate program savings, which include savings from discrete equipment, whole building, and shell measures, are different for each scenario based on parameters discussed earlier in Section 2.3. Additional discussion of the variation in rebate program savings by scenario can be found in Section 4.1.3
- BROs savings vary only in terms of reference versus aggressive. Thus, BROs savings only have two possible forecasts across the five scenarios. Additional discussion of the variation in BROs savings by scenario can be found in Section 4.1.4.
- C&S savings do not vary by scenario.

Total savings are led by C&S. Because C&S savings do not vary by scenario, the overall variability in total savings may appear minimal. True variability in savings originates from equipment rebate programs and BROs.

Versions of the following tables for each IOU can be found in Appendix H.

**Table 4-2. Statewide Net Incremental Electric Energy Savings (GWh/Year) by Scenario**

| Year | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PG Reference Scenario** | | | | | | | | | | | |
| Equipment Rebates* | 315 | 384 | 409 | 390 | 387 | 375 | 343 | 328 | 319 | 289 | 291 |
| BROs | 383 | 417 | 443 | 471 | 499 | 529 | 560 | 591 | 623 | 657 | 694 |
| ***Incentive Programs (Subtotal)*** | ***698*** | ***801*** | ***852*** | ***861*** | ***886*** | ***904*** | ***903*** | ***920*** | ***942*** | ***945*** | ***984*** |
| C&S** | 1,464 | 1,455 | 1,425 | 1,429 | 1,357 | 1,309 | 1,217 | 1,131 | 1,014 | 882 | 750 |
| **Total** | **2,163** | **2,255** | **2,277** | **2,290** | **2,243** | **2,213** | **2,120** | **2,050** | **1,956** | **1,828** | **1,734** |
| **PG Alternative Scenario 1** | | | | | | | | | | | |
| Equipment Rebates* | 381 | 457 | 452 | 428 | 419 | 408 | 374 | 360 | 346 | 308 | 309 |
| BROs | 383 | 417 | 443 | 471 | 499 | 529 | 560 | 591 | 623 | 657 | 694 |
| ***Incentive Programs (Subtotal)*** | ***764*** | ***874*** | ***896*** | ***899*** | ***917*** | ***937*** | ***934*** | ***951*** | ***969*** | ***965*** | ***1,002*** |
| C&S** | 1,464 | 1,455 | 1,425 | 1,429 | 1,357 | 1,309 | 1,217 | 1,131 | 1,014 | 882 | 750 |
| **Total** | **2,229** | **2,328** | **2,320** | **2,327** | **2,275** | **2,246** | **2,151** | **2,081** | **1,983** | **1,848** | **1,752** |
| **PG Alternative Scenario 2** | | | | | | | | | | | |
| Equipment Rebates* | 278 | 351 | 350 | 336 | 335 | 329 | 306 | 296 | 296 | 268 | 271 |
| BROs | 383 | 417 | 443 | 471 | 499 | 529 | 560 | 591 | 623 | 657 | 694 |
| ***Incentive Programs (Subtotal)*** | ***661*** | ***768*** | ***794*** | ***807*** | ***834*** | ***858*** | ***865*** | ***887*** | ***919*** | ***925*** | ***964*** |
| C&S** | 1,464 | 1,455 | 1,425 | 1,429 | 1,357 | 1,309 | 1,217 | 1,131 | 1,014 | 882 | 750 |
| **Total** | **2,126** | **2,222** | **2,219** | **2,236** | **2,191** | **2,167** | **2,083** | **2,018** | **1,933** | **1,807** | **1,714** |
| **PG Alternative Scenario 3** | | | | | | | | | | | |
| Equipment Rebates* | 324 | 393 | 416 | 395 | 389 | 375 | 343 | 328 | 320 | 290 | 293 |
| BROs | 494 | 541 | 589 | 638 | 711 | 787 | 850 | 923 | 1,010 | 1,112 | 1,236 |
| ***Incentive Programs (Subtotal)*** | ***818*** | ***934*** | ***1,005*** | ***1,033*** | ***1,100*** | ***1,163*** | ***1,192*** | ***1,251*** | ***1,330*** | ***1,403*** | ***1,529*** |
| C&S** | 1,464 | 1,455 | 1,425 | 1,429 | 1,357 | 1,309 | 1,217 | 1,131 | 1,014 | 882 | 750 |
| **Total** | **2,283** | **2,388** | **2,430** | **2,462** | **2,458** | **2,471** | **2,410** | **2,381** | **2,343** | **2,285** | **2,279** |
| **PG Alternative Scenario 4** | | | | | | | | | | | |
| Equipment Rebates* | 407 | 481 | 474 | 444 | 431 | 418 | 382 | 367 | 355 | 317 | 319 |
| BROs | 494 | 541 | 589 | 638 | 711 | 787 | 850 | 923 | 1,010 | 1,112 | 1,236 |
| ***Incentive Programs (Subtotal)*** | ***901*** | ***1,022*** | ***1,063*** | ***1,082*** | ***1,143*** | ***1,205*** | ***1,231*** | ***1,290*** | ***1,365*** | ***1,429*** | ***1,555*** |
| C&S** | 1,464 | 1,455 | 1,425 | 1,429 | 1,357 | 1,309 | 1,217 | 1,131 | 1,014 | 882 | 750 |
| **Total** | **2,365** | **2,476** | **2,487** | **2,511** | **2,500** | **2,514** | **2,448** | **2,421** | **2,378** | **2,312** | **2,305** |

*Excludes Low Income Programs
**Includes interactive effects

**Table 4-3. Statewide Net Incremental Demand Savings (MW) by Scenario**

| Year | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PG Reference Scenario** | | | | | | | | | | | |
| Equipment Rebates* | 70 | 84 | 86 | 82 | 84 | 83 | 79 | 77 | 76 | 71 | 71 |
| BROs | 72 | 78 | 83 | 88 | 93 | 99 | 104 | 110 | 116 | 122 | 128 |
| ***Incentive Programs (Subtotal)*** | ***142*** | ***162*** | ***169*** | ***171*** | ***177*** | ***181*** | ***183*** | ***187*** | ***192*** | ***193*** | ***200*** |
| C&S** | 292 | 302 | 298 | 311 | 298 | 288 | 271 | 254 | 230 | 210 | 190 |
| **Total** | **434** | **464** | **467** | **481** | **475** | **470** | **454** | **441** | **422** | **403** | **389** |
| **PG Alternative Scenario 1** | | | | | | | | | | | |
| Equipment Rebates* | 85 | 104 | 102 | 96 | 95 | 95 | 90 | 88 | 86 | 79 | 79 |
| BROs | 72 | 78 | 83 | 88 | 93 | 99 | 104 | 110 | 116 | 122 | 128 |
| ***Incentive Programs (Subtotal)*** | ***157*** | ***182*** | ***185*** | ***184*** | ***189*** | ***194*** | ***195*** | ***198*** | ***202*** | ***201*** | ***207*** |
| C&S** | 292 | 302 | 298 | 311 | 298 | 288 | 271 | 254 | 230 | 210 | 190 |
| **Total** | **449** | **485** | **483** | **495** | **487** | **482** | **465** | **452** | **432** | **411** | **397** |
| **PG Alternative Scenario 2** | | | | | | | | | | | |
| Equipment Rebates* | 62 | 78 | 77 | 74 | 74 | 74 | 71 | 71 | 71 | 67 | 67 |
| BROs | 72 | 78 | 83 | 88 | 93 | 99 | 104 | 110 | 116 | 122 | 128 |
| ***Incentive Programs (Subtotal)*** | ***134*** | ***156*** | ***160*** | ***162*** | ***167*** | ***173*** | ***176*** | ***181*** | ***187*** | ***189*** | ***195*** |
| C&S** | 292 | 302 | 298 | 311 | 298 | 288 | 271 | 254 | 230 | 210 | 190 |
| **Total** | **426** | **458** | **458** | **472** | **466** | **461** | **447** | **435** | **417** | **399** | **385** |
| **PG Alternative Scenario 3** | | | | | | | | | | | |
| Equipment Rebates* | 71 | 85 | 87 | 83 | 84 | 83 | 79 | 78 | 77 | 72 | 72 |
| BROs | 89 | 97 | 106 | 115 | 126 | 139 | 149 | 162 | 177 | 194 | 215 |
| ***Incentive Programs (Subtotal)*** | ***160*** | ***183*** | ***193*** | ***198*** | ***211*** | ***222*** | ***229*** | ***240*** | ***253*** | ***266*** | ***287*** |
| C&S** | 292 | 302 | 298 | 311 | 298 | 288 | 271 | 254 | 230 | 210 | 190 |
| **Total** | **453** | **485** | **492** | **509** | **509** | **510** | **500** | **494** | **484** | **476** | **477** |
| **PG Alternative Scenario 4** | | | | | | | | | | | |
| Equipment Rebates* | 89 | 109 | 106 | 100 | 99 | 98 | 93 | 90 | 88 | 81 | 80 |
| BROs | 89 | 97 | 106 | 115 | 126 | 139 | 149 | 162 | 177 | 194 | 215 |
| ***Incentive Programs (Subtotal)*** | ***178*** | ***206*** | ***212*** | ***214*** | ***225*** | ***236*** | ***242*** | ***252*** | ***264*** | ***275*** | ***295*** |
| C&S** | 292 | 302 | 298 | 311 | 298 | 288 | 271 | 254 | 230 | 210 | 190 |
| **Total** | **470** | **508** | **510** | **525** | **523** | **525** | **513** | **506** | **495** | **485** | **485** |

*Excludes Low Income Programs
**Includes interactive effects

**Table 4-4. Statewide Net Incremental Gas Energy Savings (MMtherm/Year) by Scenario**

| Year | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PG Reference Scenario** | | | | | | | | | | | |
| Equipment Rebates* | 11.1 | 13.6 | 16.7 | 18.7 | 18.4 | 18.2 | 17.2 | 16.8 | 16.3 | 15.6 | 17.0 |
| BROs | 16.1 | 16.8 | 17.4 | 18.1 | 18.8 | 19.5 | 20.3 | 21.2 | 22.1 | 23.1 | 24.2 |
| ***Incentive Programs (Subtotal)*** | ***27.2*** | ***30.5*** | ***34.2*** | ***36.8*** | ***37.1*** | ***37.7*** | ***37.5*** | ***38.0*** | ***38.4*** | ***38.8*** | ***41.3*** |
| C&S** | 35.5 | 36.5 | 36.8 | 37.8 | 39.3 | 38.2 | 31.7 | 28.4 | 26.3 | 23.2 | 23.4 |
| **Total** | **62.8** | **67.0** | **71.0** | **74.6** | **76.5** | **75.9** | **69.3** | **66.4** | **64.7** | **62.0** | **64.6** |
| **PG Alternative Scenario 1** | | | | | | | | | | | |
| Equipment Rebates* | 18.2 | 20.4 | 20.3 | 19.6 | 19.4 | 21.0 | 21.2 | 20.3 | 20.6 | 19.1 | 19.7 |
| BROs | 16.1 | 16.8 | 17.4 | 18.1 | 18.8 | 19.5 | 20.3 | 21.2 | 22.1 | 23.1 | 24.2 |
| ***Incentive Programs (Subtotal)*** | ***34.3*** | ***37.2*** | ***37.7*** | ***37.6*** | ***38.1*** | ***40.5*** | ***41.5*** | ***41.5*** | ***42.8*** | ***42.2*** | ***43.9*** |
| C&S** | 35.5 | 36.5 | 36.8 | 37.8 | 39.3 | 38.2 | 31.7 | 28.4 | 26.3 | 23.2 | 23.4 |
| **Total** | **69.8** | **73.7** | **74.5** | **75.5** | **77.4** | **78.8** | **73.2** | **69.9** | **69.1** | **65.4** | **67.3** |
| **PG Alternative Scenario 2** | | | | | | | | | | | |
| Equipment Rebates* | 8.9 | 10.6 | 10.6 | 11.4 | 11.7 | 12.3 | 14.0 | 13.8 | 15.1 | 14.8 | 15.8 |
| BROs | 16.1 | 16.8 | 17.4 | 18.1 | 18.8 | 19.5 | 20.3 | 21.2 | 22.1 | 23.1 | 24.2 |
| ***Incentive Programs (Subtotal)*** | ***25.0*** | ***27.4*** | ***28.1*** | ***29.4*** | ***30.4*** | ***31.8*** | ***34.3*** | ***35.0*** | ***37.2*** | ***37.9*** | ***40.0*** |
| C&S** | 35.5 | 36.5 | 36.8 | 37.8 | 39.3 | 38.2 | 31.7 | 28.4 | 26.3 | 23.2 | 23.4 |
| **Total** | **60.5** | **63.9** | **64.9** | **67.2** | **69.8** | **70.0** | **66.0** | **63.3** | **63.6** | **61.1** | **63.4** |
| **PG Alternative Scenario 3** | | | | | | | | | | | |
| Equipment Rebates* | 11.2 | 13.8 | 16.9 | 18.9 | 18.4 | 18.2 | 17.2 | 16.8 | 16.2 | 15.6 | 17.0 |
| BROs | 18.5 | 19.7 | 21.0 | 22.3 | 24.1 | 26.2 | 28.4 | 31.1 | 34.3 | 38.1 | 42.7 |
| ***Incentive Programs (Subtotal)*** | ***29.7*** | ***33.5*** | ***37.9*** | ***41.1*** | ***42.5*** | ***44.4*** | ***45.6*** | ***47.8*** | ***50.6*** | ***53.8*** | ***59.8*** |
| C&S** | 35.5 | 36.5 | 36.8 | 37.8 | 39.3 | 38.2 | 31.7 | 28.4 | 26.3 | 23.2 | 23.4 |
| **Total** | **65.2** | **70.0** | **74.7** | **79.0** | **81.8** | **82.6** | **77.3** | **76.2** | **76.9** | **77.0** | **83.1** |
| **PG Alternative Scenario 4** | | | | | | | | | | | |
| Equipment Rebates* | 19.2 | 21.3 | 21.1 | 20.3 | 19.9 | 21.4 | 21.4 | 20.4 | 20.7 | 19.1 | 19.7 |
| BROs | 18.5 | 19.7 | 21.0 | 22.3 | 24.1 | 26.2 | 28.4 | 31.1 | 34.3 | 38.1 | 42.7 |
| ***Incentive Programs (Subtotal)*** | ***37.7*** | ***41.0*** | ***42.1*** | ***42.6*** | ***44.0*** | ***47.6*** | ***49.8*** | ***51.5*** | ***55.1*** | ***57.2*** | ***62.4*** |
| C&S** | 35.5 | 36.5 | 36.8 | 37.8 | 39.3 | 38.2 | 31.7 | 28.4 | 26.3 | 23.2 | 23.4 |
| **Total** | **73.2** | **77.5** | **78.9** | **80.4** | **83.3** | **85.9** | **81.5** | **79.9** | **81.4** | **80.4** | **85.8** |

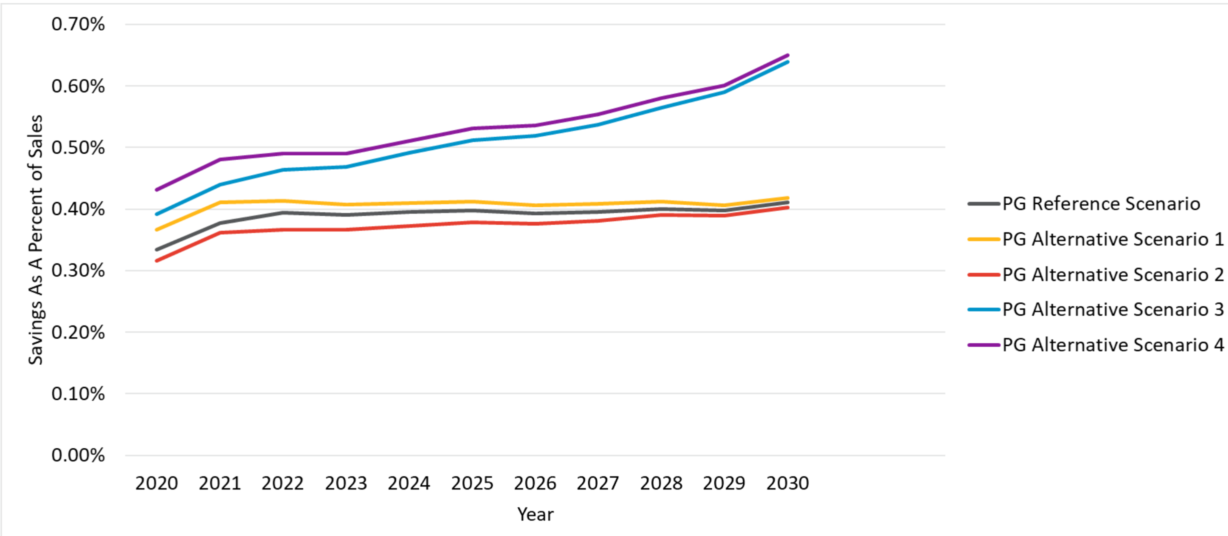
*Exclude Low Income Programs

**Includes interactive effects

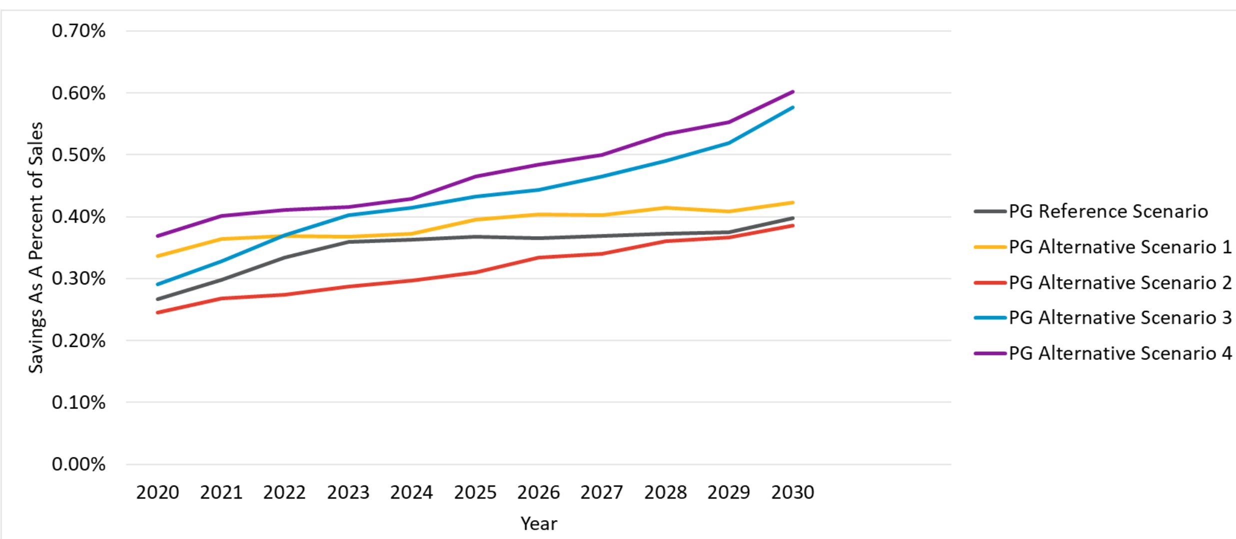
Figure 4-1 and Figure 4-2 compare the savings from all incentive programs, which includes savings from equipment rebate programs, BROs interventions, and low income programs, as a percentage of IOU sales. Savings as a percentage of sales is a common metric provided in other potential studies, and industry standard practice is to exclude savings from C&S from such calculations. Energy sales are sourced from the CEC's IEPR mid-case.

**Figure 4-1. Incremental Electric Market Potential as a Percentage of Sales**




Note: Excludes C&S and Low Income savings

**Figure 4-2. Incremental Gas Market Potential as a Percentage of Sales**

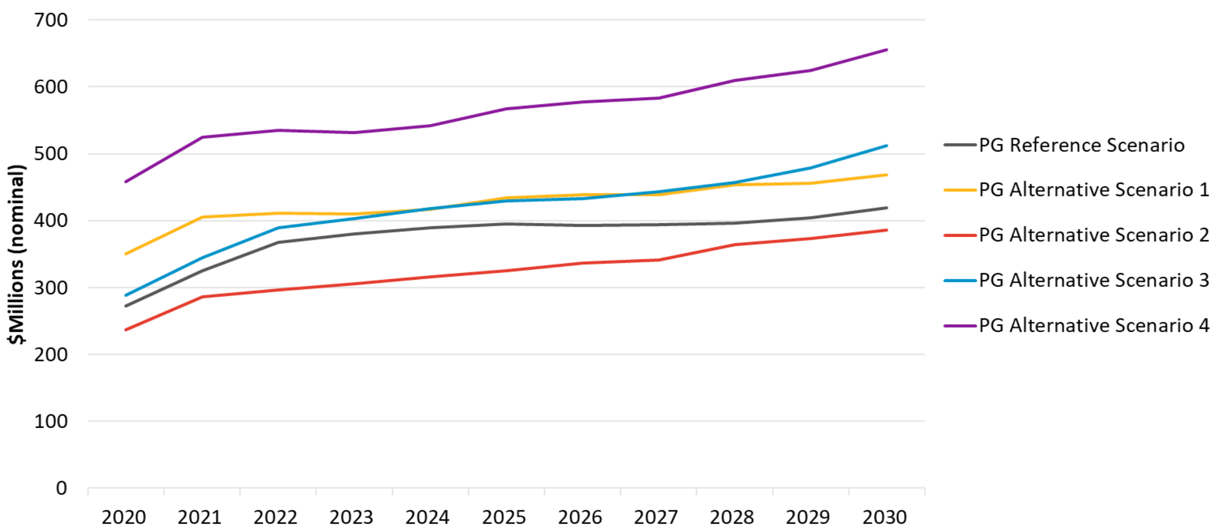



Note: Excludes C&S and Low Income savings

Figure 4-3 shows projected statewide spending for equipment rebate programs, BROs, and low income programs by scenario. Spending includes both incentive and non-incentive resource program costs, which were approximated from historic program activity spending data from the IOUs. Alternative

Scenario 4 produces the most expensive portfolio for equipment savings and the Alternative Scenario 2, the least. Alternative 3 is requires slightly more budget than the Reference but produces proportionally more savings. This is because Alternative 3 is more aggressive with BROs and other aspects of program design without increasing incentive levels. This implies it can achieve higher first-year savings at a lower cost relative to the Reference Scenario.

**Figure 4-3. Statewide Spending by Scenario for IOU Incentive Programs**




Note: Excludes C&S and Low Income savings

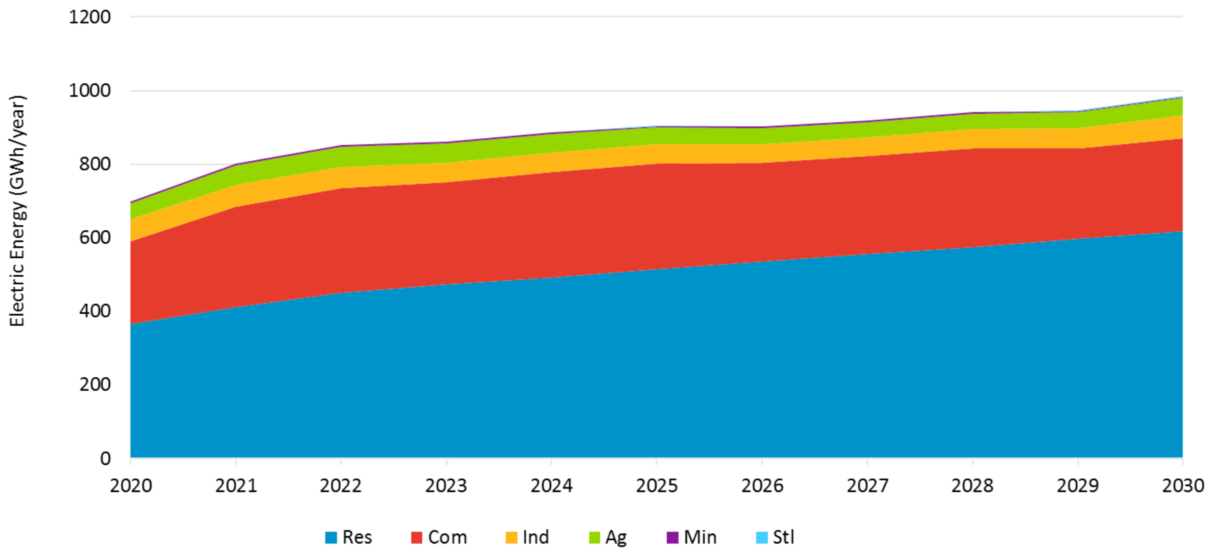
### *4.1.2 Total Savings and Spending by Sector*

Figure 4-4 through Figure 4-12 show the breakdown of electric (GWh) and gas (MMtherms) savings, respectively, by sector for incentive programs, which includes savings from equipment rebate programs, and BROs interventions. All figures exclude savings from re-participants.

For electric savings, the commercial and residential sectors lead the savings across all scenarios, with the residential sector showing slightly higher potential over the study horizon due to the large amount of BROs savings that fall in the residential sector. The incremental savings potential grows over time for the residential, commercial, and agricultural sectors. This growth is largely attributable to greater levels of market uptake for BROs in the later years. Conversely, the incremental savings potential declines for the industrial, mining and street lighting sectors. For industrial and mining, this savings decline is highly correlated with flat or negative customer growth rates during the time horizon. For street lighting, the market potential for high efficiency measures becomes more saturated over time.

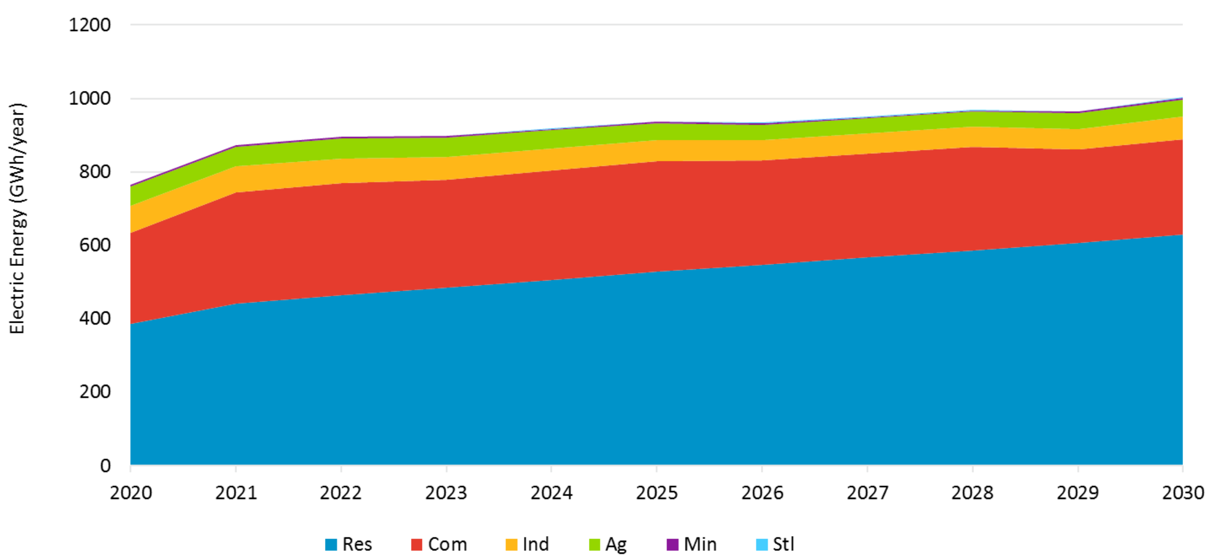
For gas savings, the largest savings potential comes from the industrial and residential sectors. Like electric savings, BROs contributes significantly to future growth of savings potential.

**Figure 4-4. Statewide Incremental Net Electric Market Potential by Sector for Incentive Programs (Reference)**



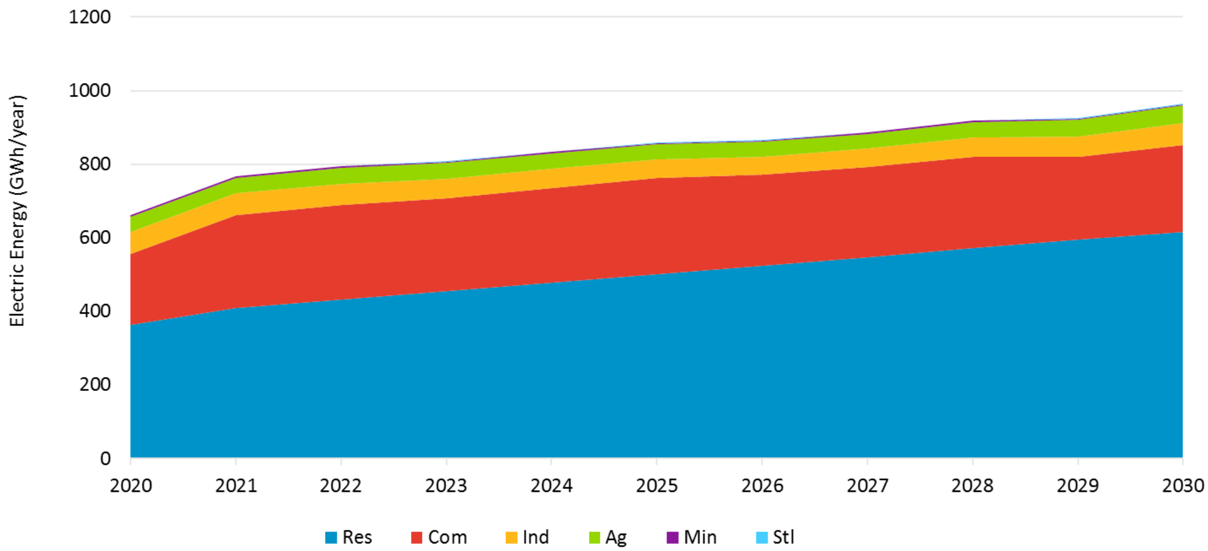

Note: Excludes C&S and Low Income savings

**Figure 4-5. Statewide Incremental Net Electric Market Potential by Sector for Incentive Programs (Alternative 1)**



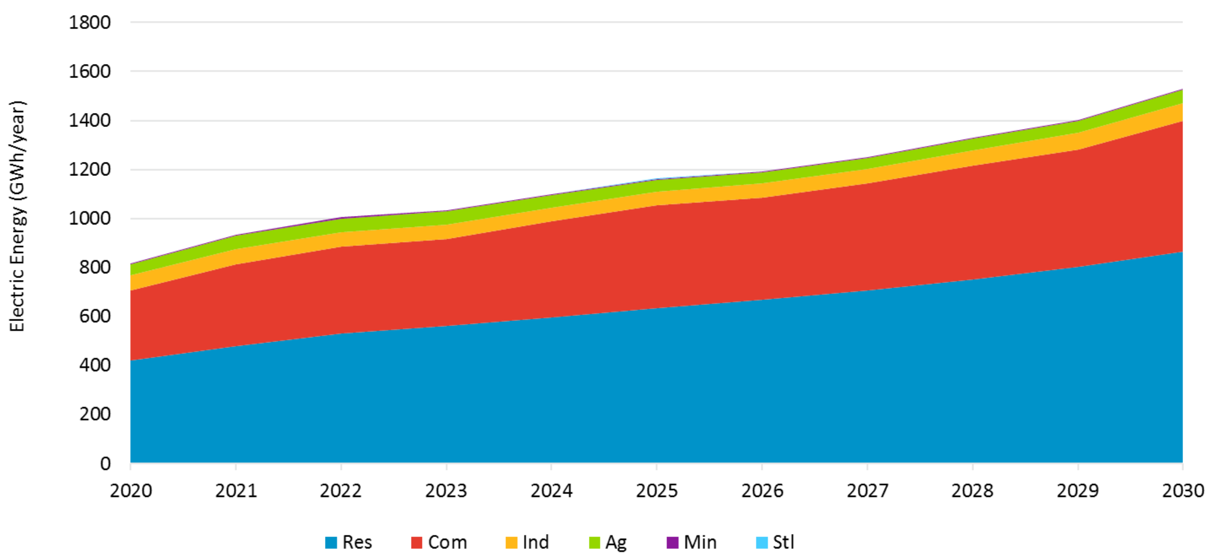

Note: Excludes C&S and Low Income savings

**Figure 4-6. Statewide Incremental Electric Market Potential by Sector for Incentive Programs (Alternative 2)**



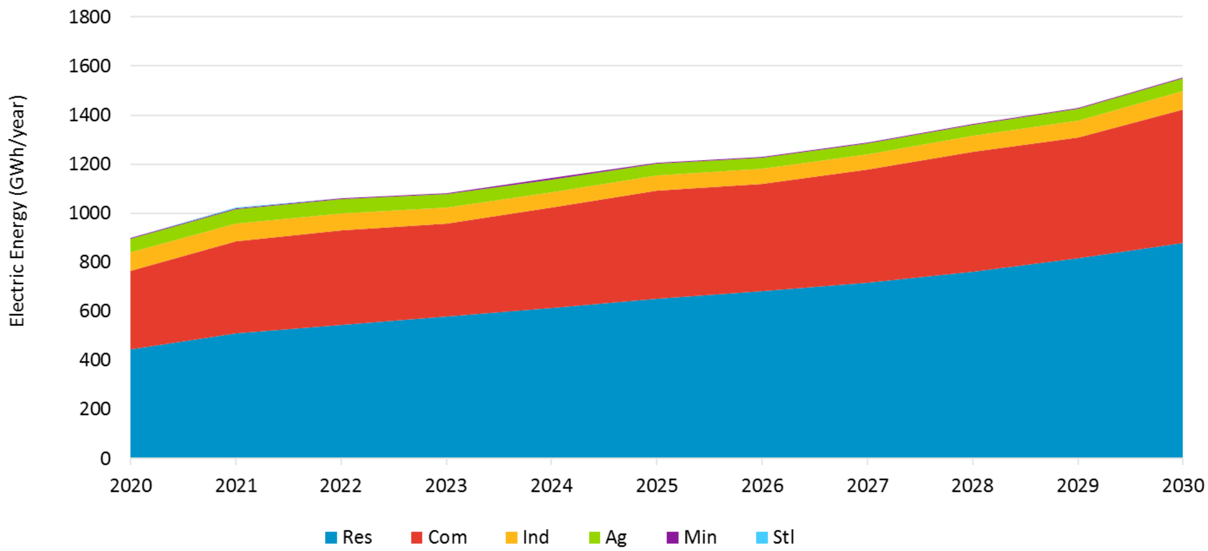

Note: Excludes C&S and Low Income savings

**Figure 4-7. Statewide Incremental Electric Market Potential by Sector for Incentive Programs (Alternative 3)**



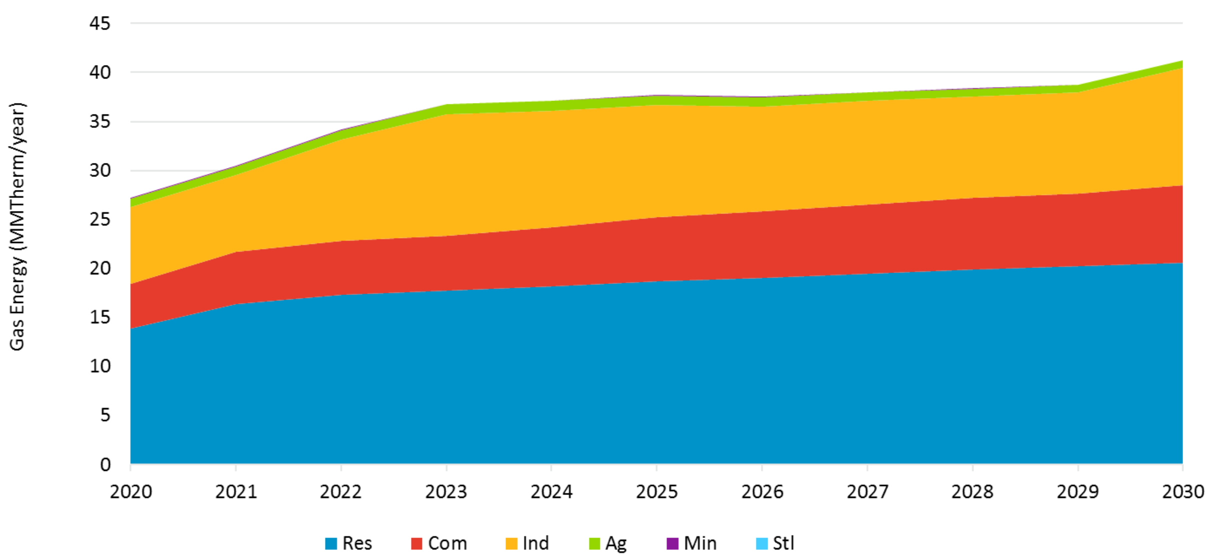

Note: Excludes C&S and Low Income savings

**Figure 4-8. Statewide Incremental Electric Market Potential by Sector for Incentive Programs (Alternative 4)**




Note: Excludes C&S and Low Income savings

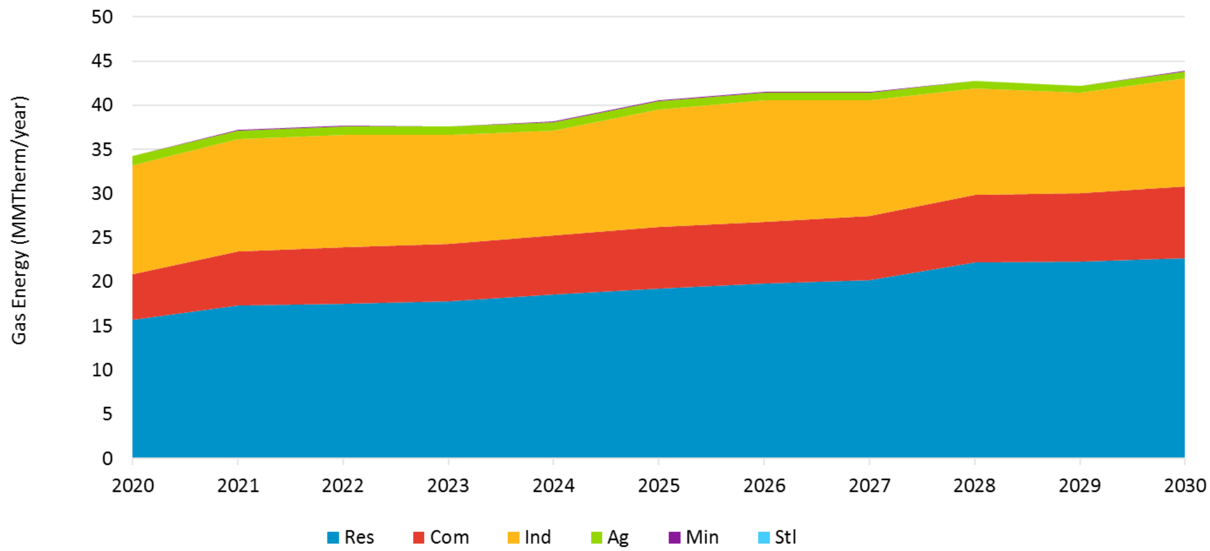
**Figure 4-9. Statewide Incremental Gas Market Potential by Sector for Incentive Programs (Reference)**




Note: Excludes C&S and Low Income savings

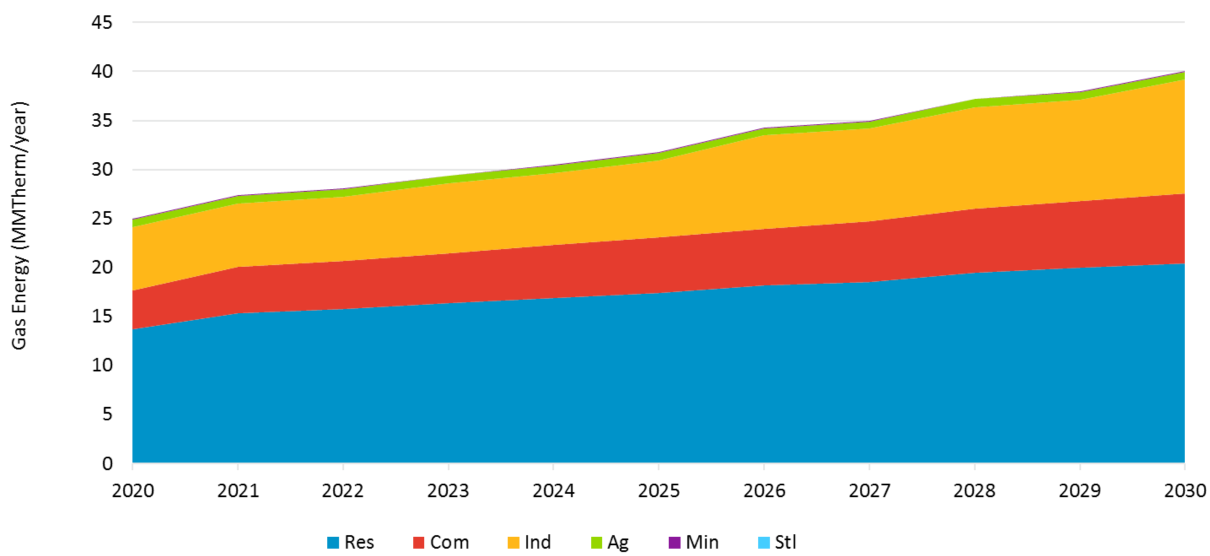
 

**Figure 4-10. Statewide Incremental Gas Market Potential by Sector for Incentive Programs (Alternative 1)**



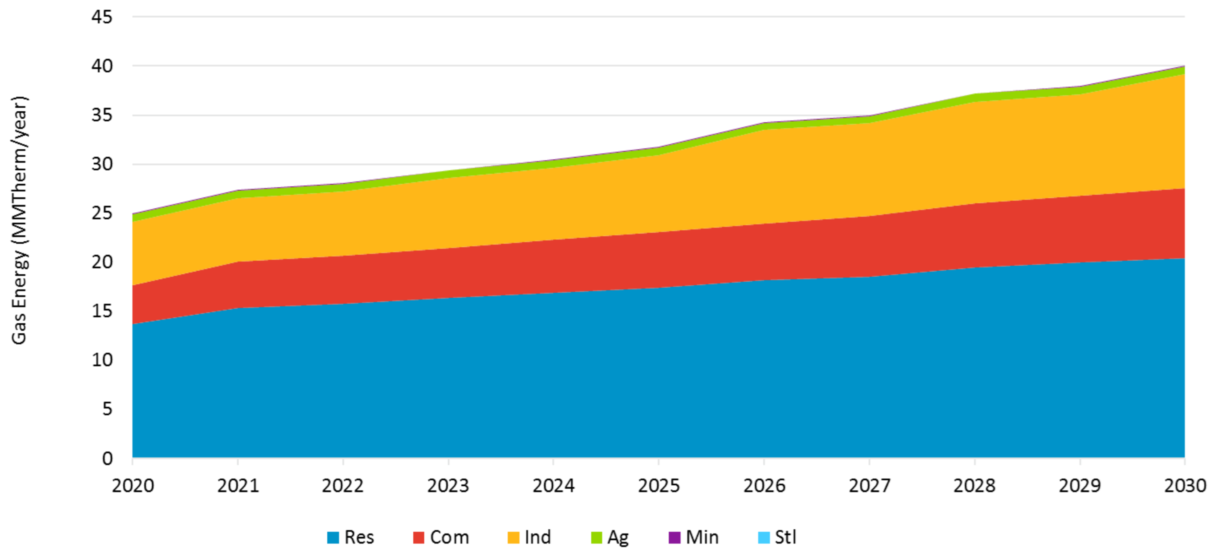

Note: Excludes C&S and Low Income savings

**Figure 4-11. Statewide Incremental Gas Market Potential by Sector for Incentive Programs (Alternative 2)**



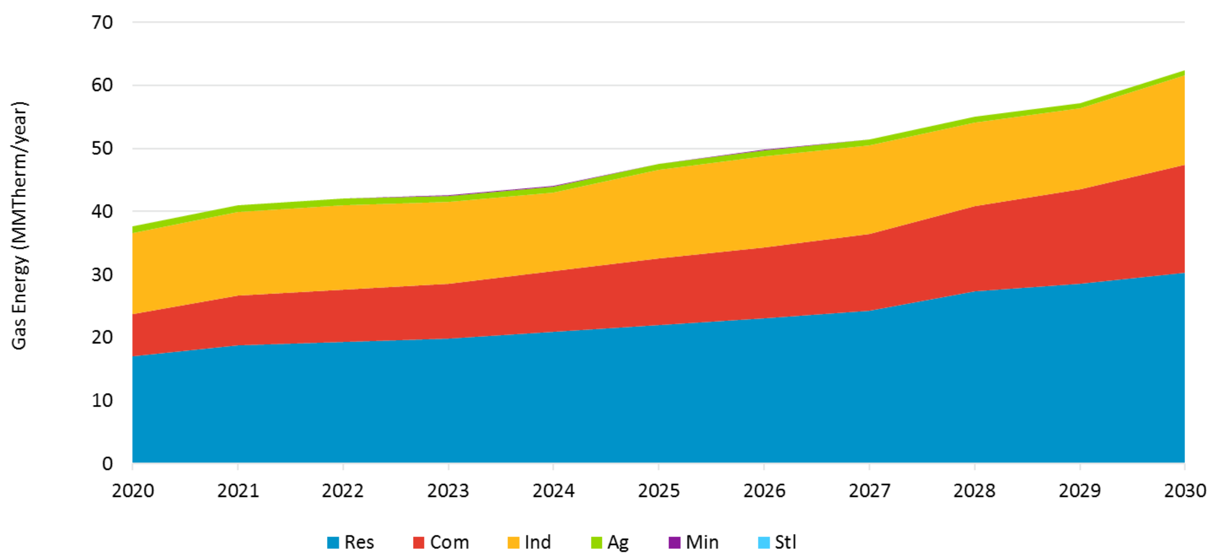

Note: Excludes C&S and Low Income savings

**Figure 4-12. Statewide Incremental Gas Market Potential by Sector for Incentive Programs (Alternative 3)**




Note: Excludes C&S and Low Income savings

**Figure 4-13. Statewide Incremental Gas Market Potential by Sector for Incentive Programs (Alternative 4)**



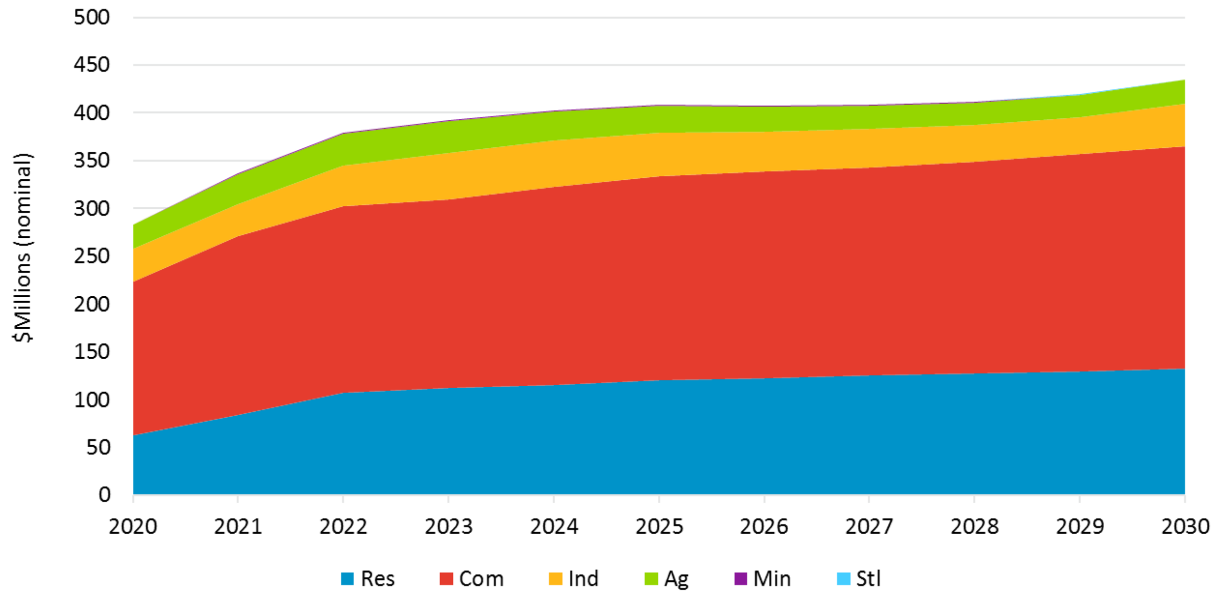

Note: Excludes C&S and Low Income savings

A peak demand savings version of the above figures can be found in the results explorer.

Figure 4-14 through Figure 4-18 show the breakdown of statewide spending by sector for incentive programs, which includes savings from equipment rebate programs and BROs interventions. This data does not include costs associated with non-resource programs or C&S advocacy.

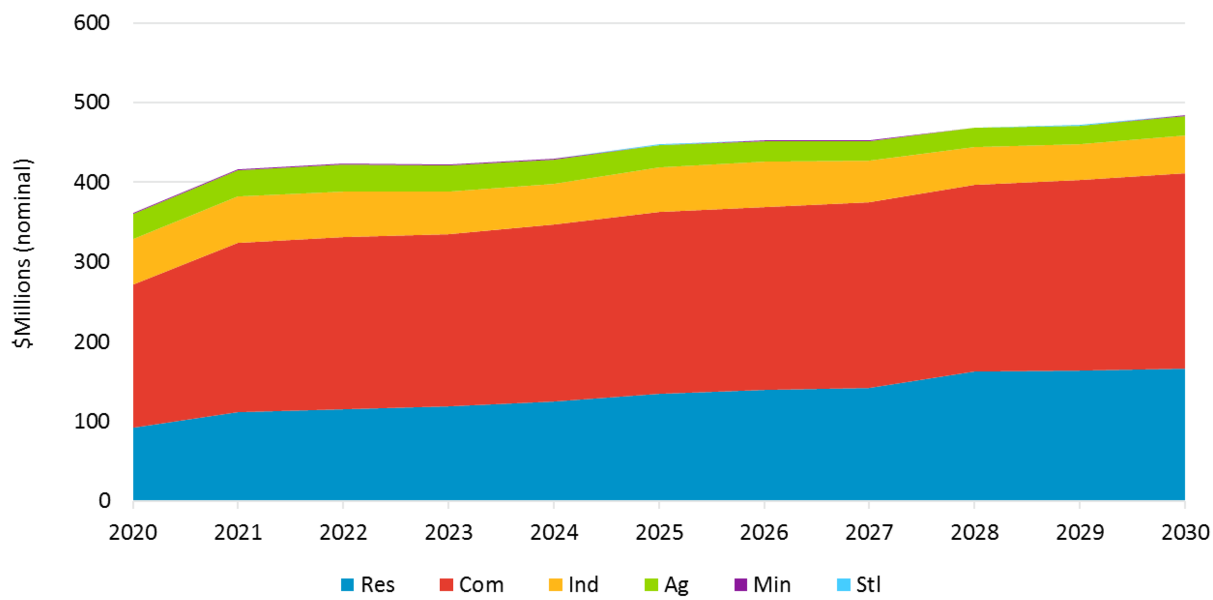
Once again, a key takeaway from these figures is that the share of each sector's savings generally remains the same across scenarios.

Figure 4-14. Statewide Spending by Sector for Incentive Programs (Reference)



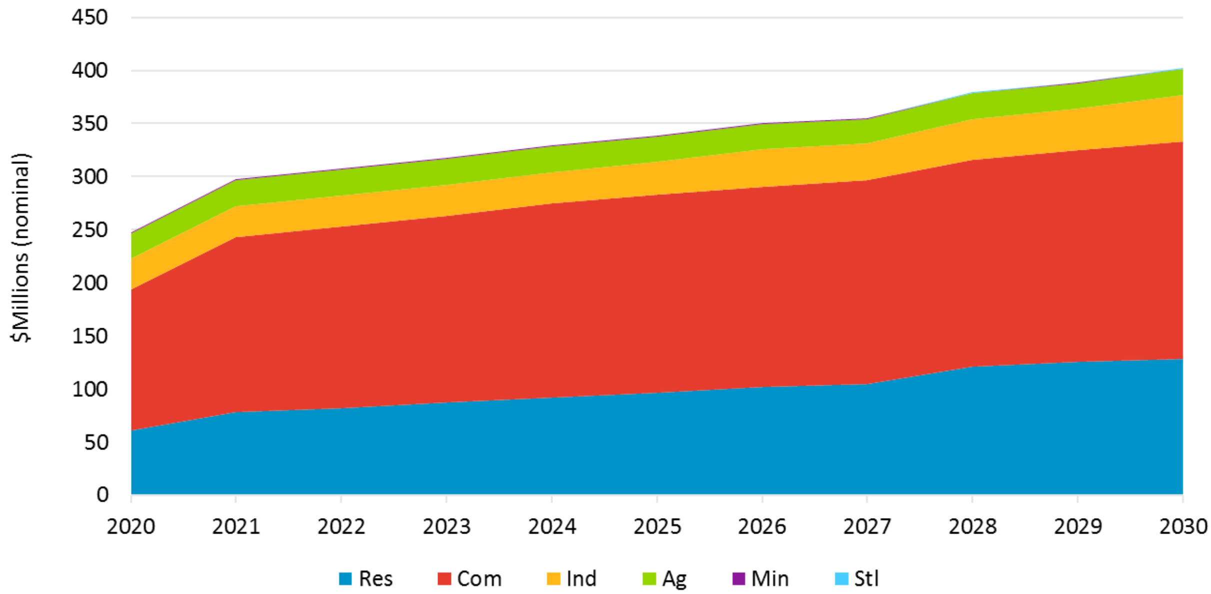

Note: Excludes C&S advocacy, Low Income, and non-resource program costs

Figure 4-15. Statewide Spending by Sector for Incentive Programs (Alternative 1)



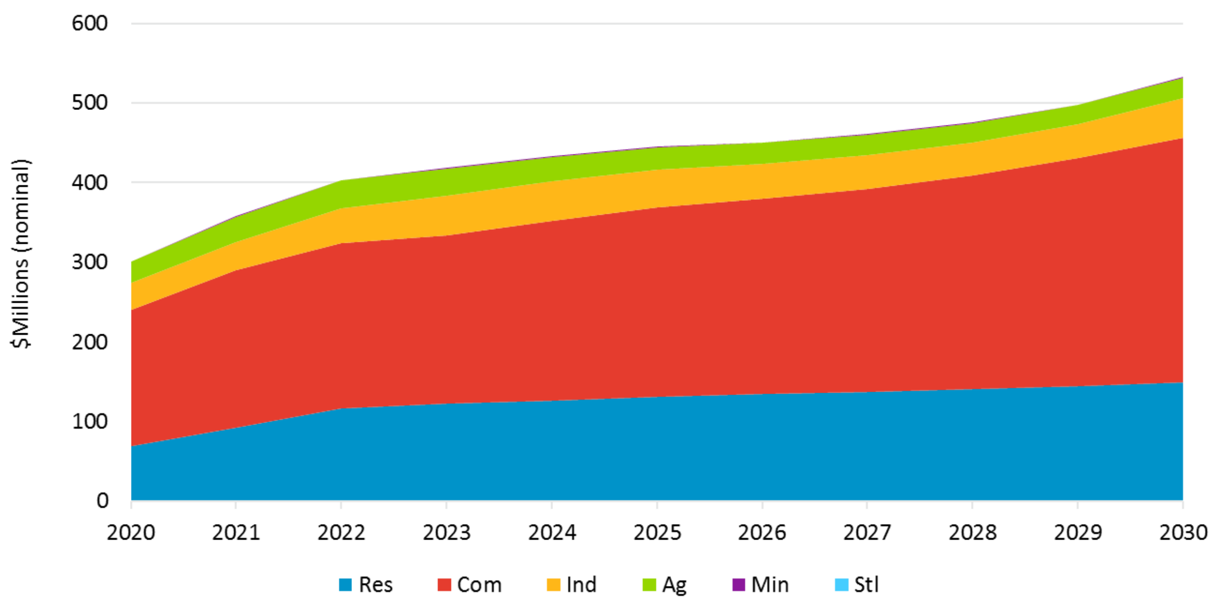

Note: Excludes C&S advocacy, Low Income, and non-resource program costs

**Figure 4-16. Statewide Spending by Sector for Incentive Programs (Alternative 2)**



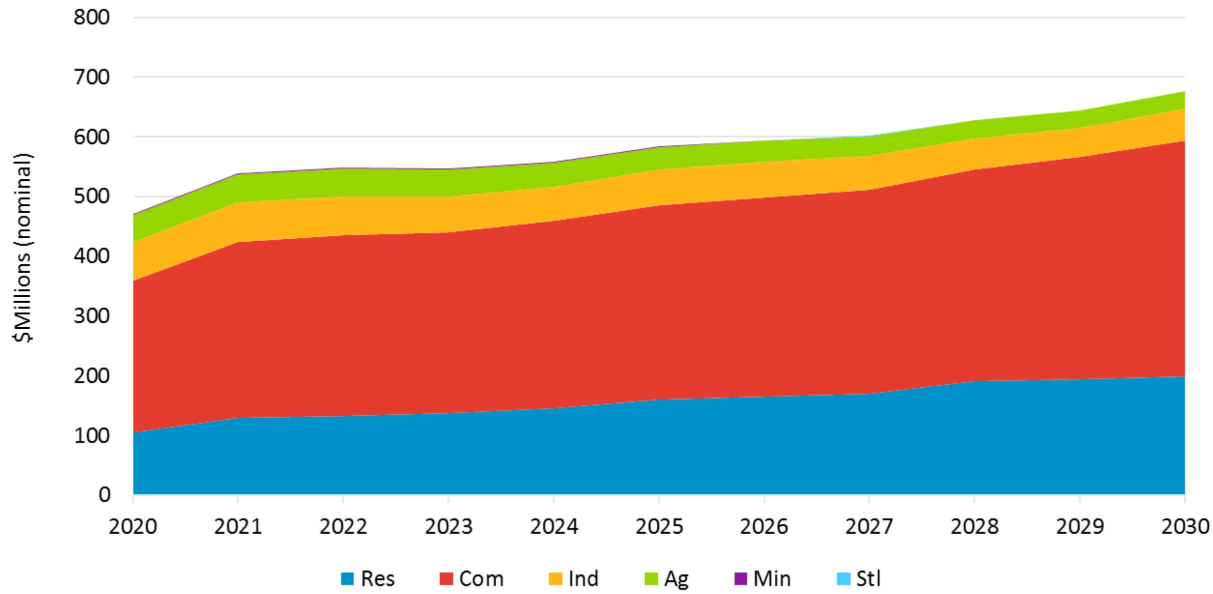

Note: Excludes C&S advocacy, Low Income, and non-resource program costs

**Figure 4-17. Statewide Spending by Sector for Incentive Programs (Alternative 3)**




Note: Excludes C&S advocacy, Low Income, and non-resource program costs

**Figure 4-18. Statewide Spending by Sector for Incentive Programs (Alternative 4)**



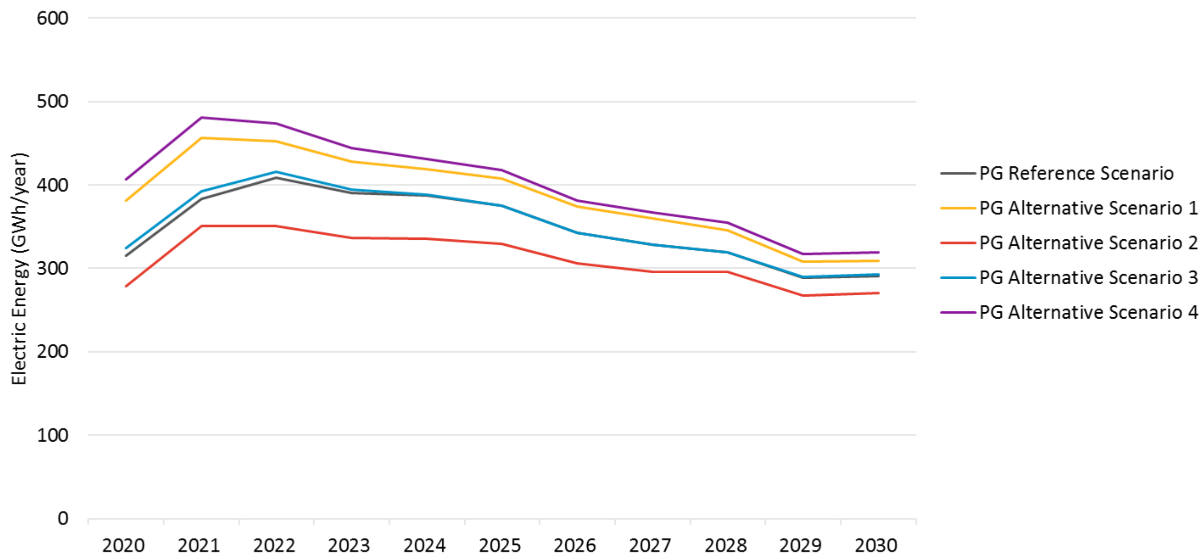

Note: Excludes C&S advocacy, Low Income, and non-resource program costs

### *4.1.3 Equipment Rebate Program Results*

Figure 4-19 and Figure 4-20 illustrate the statewide incremental market potential from equipment rebate program savings, which includes savings from discrete equipment, whole building, and shell measures, by scenario for electric (GWh) and gas (MMtherms), respectively. These figures exclude IOU-claimable savings from C&S advocacy programs and BROs interventions. They also exclude savings from re-participants, as the Navigant team was tasked to assess incremental potential from first-time adopters in the market. Cumulative savings are presented in Appendix B.

Figure 4-19 shows that electric potential increases as the TRC threshold used to screen measures becomes less stringent. Alternative 1 uses the least restrictive threshold, while Alternative 2 uses the most restrictive. Alternative 3 shows slightly higher savings than the Reference scenario in early years. These two scenarios are similar except Alternate 3 assumes more aggressive program marketing and outreach, which manifests itself in a slight front loading of savings in earlier years. Overall, Alternative 4 produces about 46% more electric savings than Alternative 2 (the most conservative scenario) in 2020.

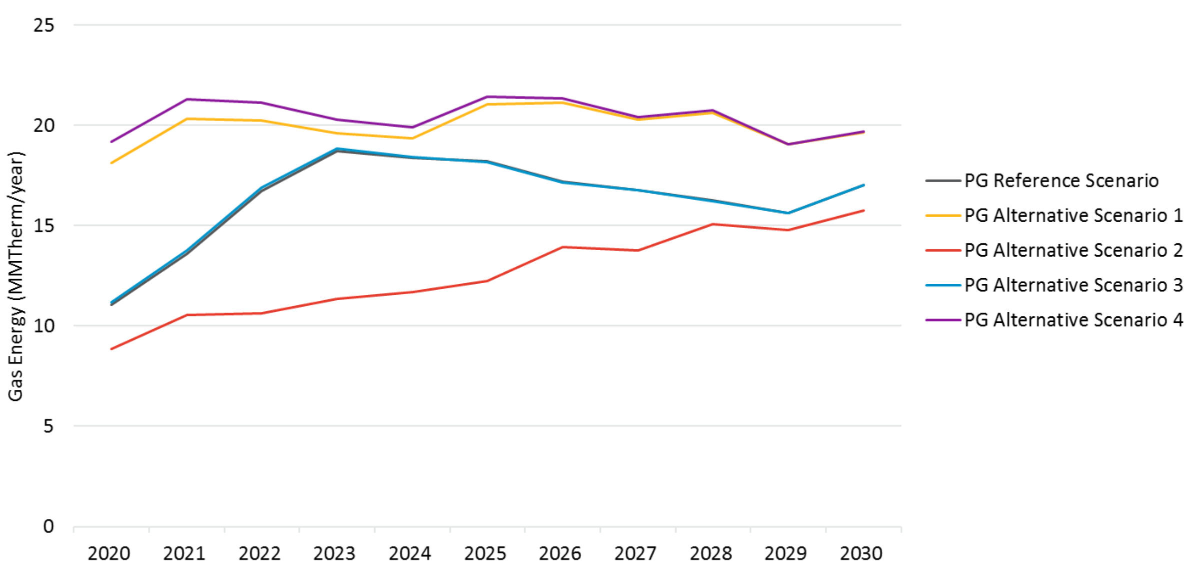
**Figure 4-19.Statewide Incremental Electric Market Potential by Scenario**




Note: Excludes BROs, Low Income, and C&S

Like Figure 4-19, Figure 4-20 shows that gas potential generally increases as the cost test used to screen measures becomes less stringent. Alternative 1 uses the least restrictive threshold, while Alternative 2 uses the most restrictive. Overall, Alternative 4 produces about 116% more gas savings than Alternative 2 (the most conservative scenario) in 2020. The spread in gas savings across the five scenarios is larger than the spread observed in electric savings. This is because there are more gas measures and savings that have measure-level TRCs in the range of 0.85 and 1.25 relative to electric measures and savings. Thus, gas savings are far more sensitive to the TRC threshold.

**Figure 4-20. Statewide Incremental Gas Market Potential by Scenario**




Note: Excludes BROs, Low Income, and C&S

Note that the Navigant team also produced cumulative market potential as part of the study for equipment rebate program measures and compared it against technical and economic potential for all five scenarios. Details on these results can be found in Appendix B.

The following subsections discuss the statewide program and end-use-level potential results for electric (GWh) and gas (MMtherms) savings for equipment rebate programs in different sectors. Additional versions of this figure for each IOU and for peak demand savings can be found in the results viewer. Note that measure-level results are available in a database that accompanies this report.

#### *4.1.3.1 Residential Rebate Programs*

Figure 4-21 through Figure 4-25 shows the breakdown of electric savings by end use in the residential sector for each scenario. They exclude BROs (covered in Section 4.1.4) and low income (covered in Section 5.2). Key observations from these figures include the following:

- Per guidance from the CPUC staff and in response to stakeholder comments, this model assumed LEDs are the market baseline technology for residential lighting. The very small amount of lighting potential is driven by LEDs with embedded controls (which provide savings above and beyond standards LEDs). The removal of lighting visually exaggerates the contributions of remaining end uses in all graphs.
- Among end-use categories that capture potential from discrete measures, appliance measures leads electric potential in the residential sector in 2020 followed by whole building across all scenarios.
- Residential whole building potential contributes somewhat significantly to potential in the later years of the forecast across all scenarios. Whole building savings are driven by opportunities for new construction EE saving above and beyond 2019 Title 24 building codes. The model does not forecast any savings from residential whole building retrofit programs (like Energy Upgrade California) as they are found to not be cost-effective across any of the five scenarios. Residential whole building potential is lower than in past studies because the potential was reduced to account for LEDs being assumed to be the baseline for residential lighting.
- For certain end uses the model simulates an increasingly saturated market over time as more customers begin adopting efficient equipment with limited remaining low efficiency equipment to convert. This leads to decreases in potential for select end uses in latter years.
- There is a high degree of variation between scenarios for HVAC savings. As the C-E screening test gets less stringent, more expensive HVAC measures are included in the potential.

**Figure 4-21. Statewide Residential Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Reference)**

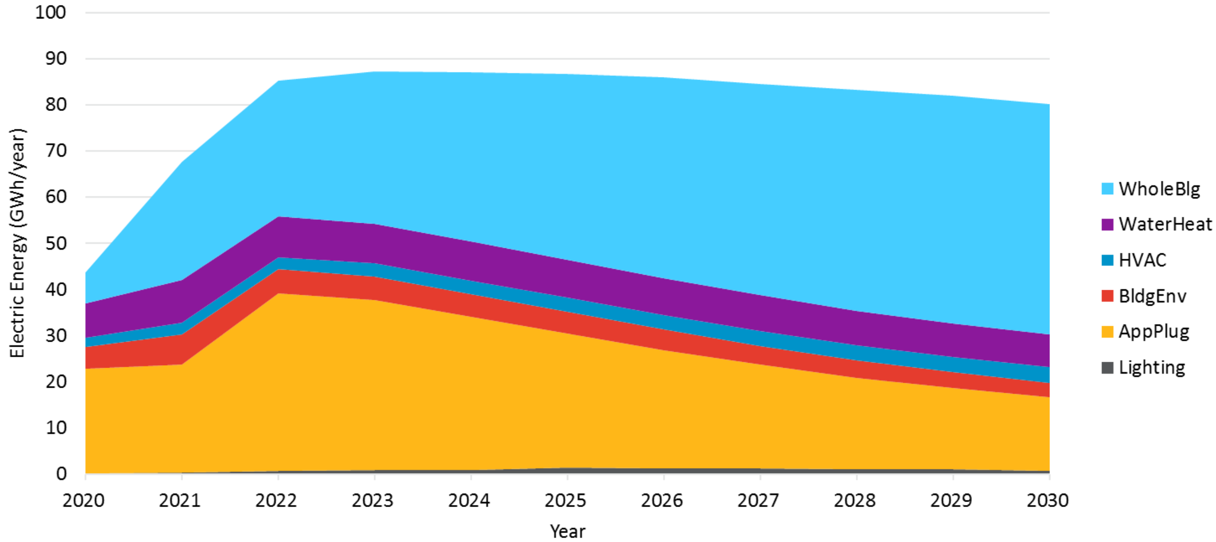



**Figure 4-22. Statewide Residential Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 1)**

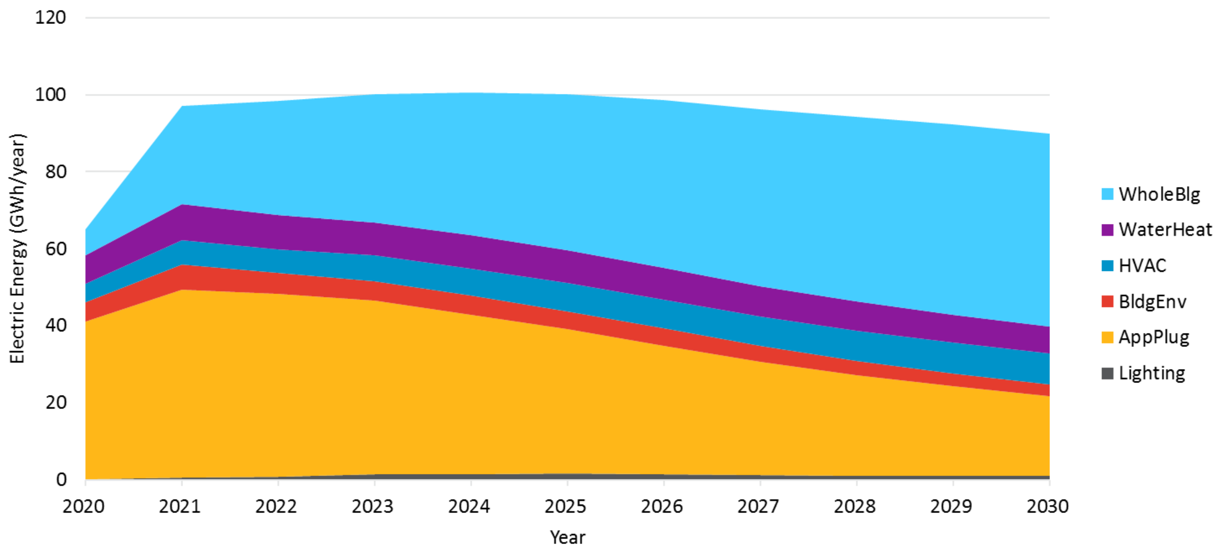


**Figure 4-23. Statewide Residential Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 2)**

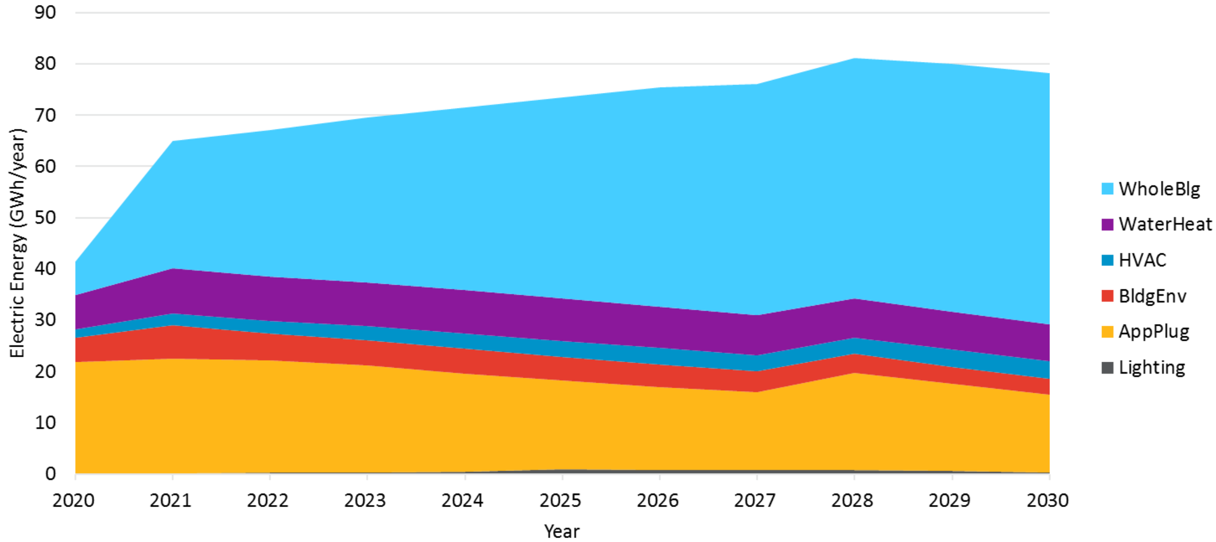



**Figure 4-24. Statewide Residential Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 3)**

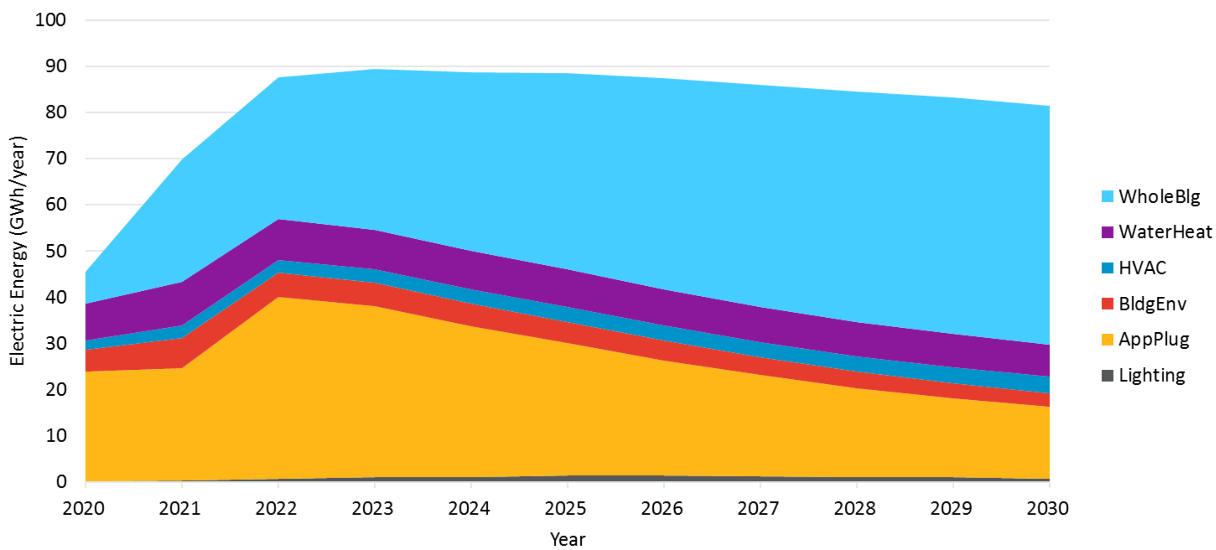


**Figure 4-25. Statewide Residential Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 4)**

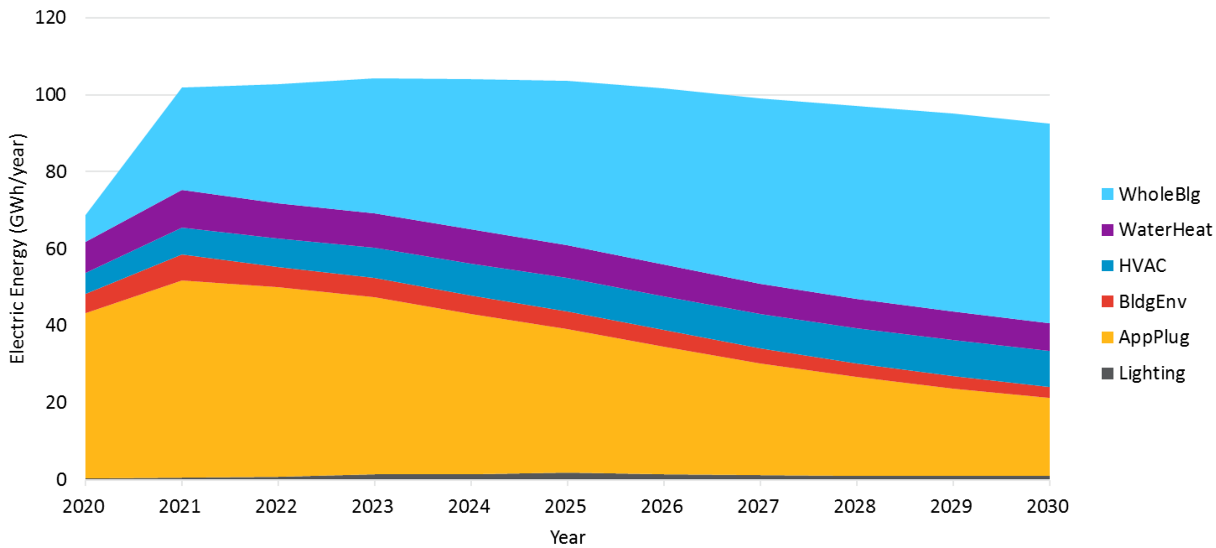



Figure 4-26 through Figure 4-30 show the breakdown of gas savings by end use in the residential sector. Key observations from these figures include the following:

- Among end-use categories that capture potential from discrete measures, appliances and building envelope regularly appear across all scenarios. Water heating is sensitive to the TRC threshold, so in some scenarios water heating dominates while in others it plays a small role.
- HVAC potential does not show up until 2025 in Alternative 1 and Alternative 4 because no measures screen the TRC test prior to that. It does not show up at any point during the forecast period for all other scenarios, indicating that no measures screen the TRC test for those scenarios.
- Residential whole building potential contributes significantly to overall potential. Like electric savings, whole building gas savings are driven by opportunities for new construction EE saving above and beyond 2019 Title 24 building codes. The model does not forecast any savings from residential whole building retrofit programs (like Energy Upgrade California) as they are found to not be cost-effective across any of the five scenarios.

**Figure 4-26. Statewide Residential Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Reference)**

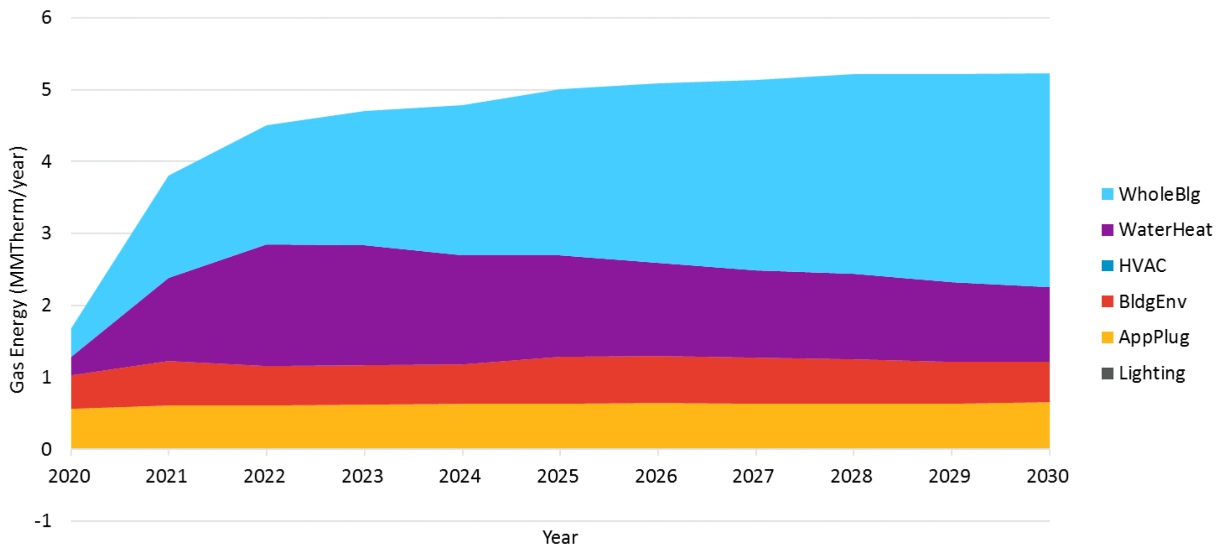



**Figure 4-27. Statewide Residential Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 1)**

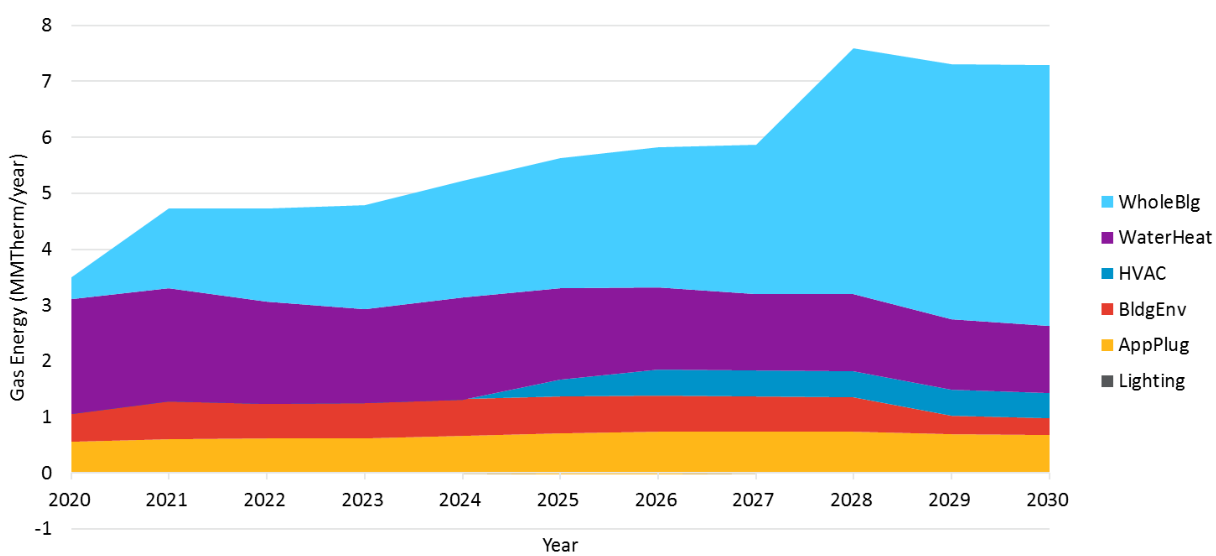


**Figure 4-28. Statewide Residential Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 2)**

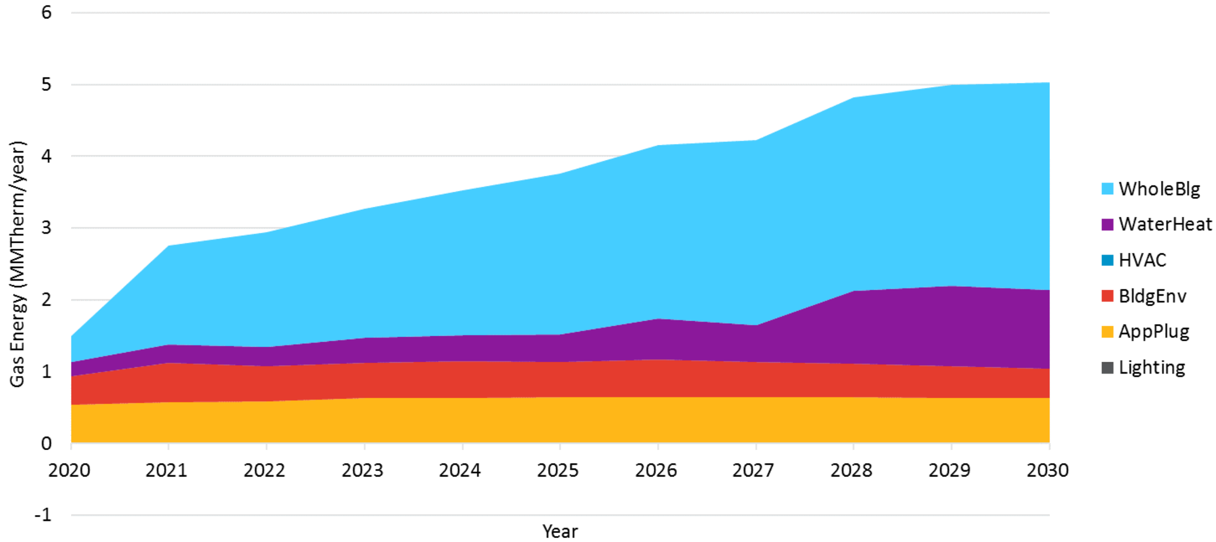



**Figure 4-29. Statewide Residential Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 3)**

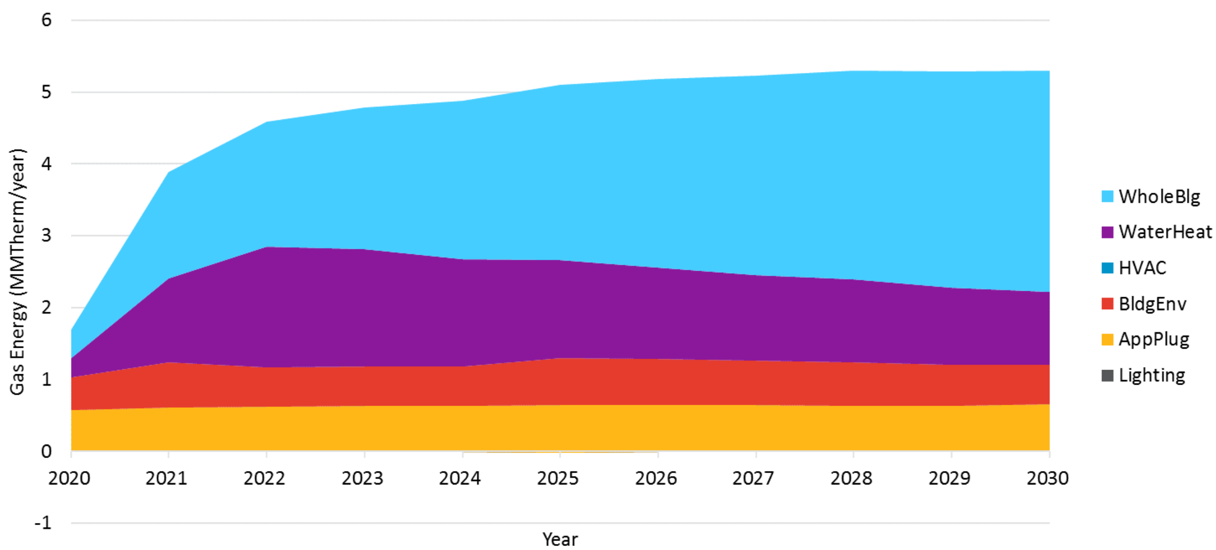
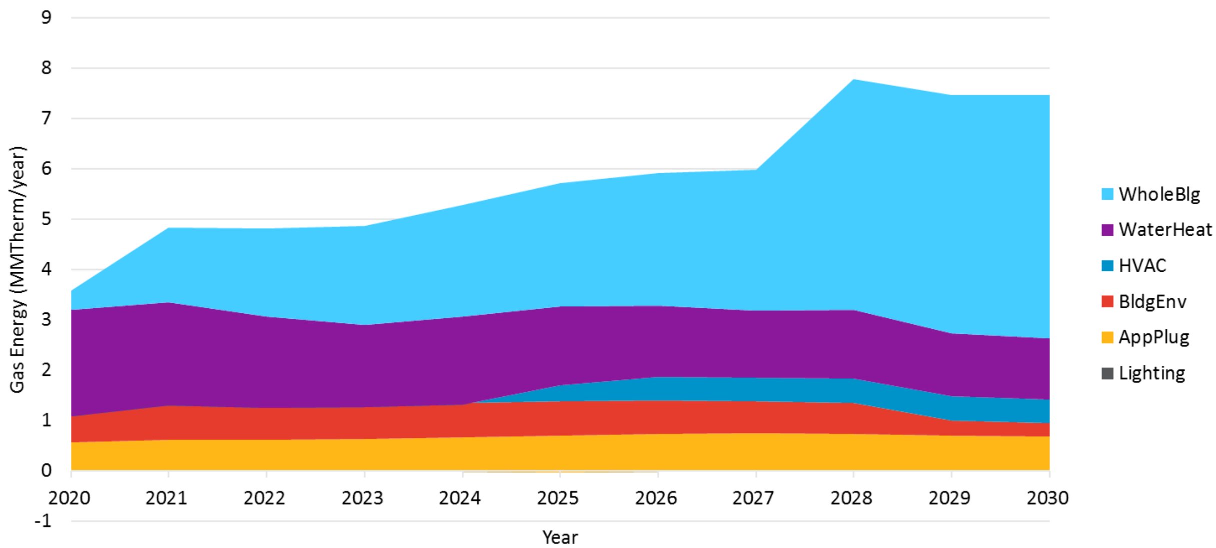


**Figure 4-30. Statewide Residential Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 4)**




### *4.1.3.2 Commercial Rebate Programs*

Figure 4-31 through Figure 4-35 show the breakdown of electric savings by end use in the commercial sector for each scenario. Key observations from these figures include the following:

- Among end-use categories that capture potential from discrete measures, HVAC and commercial refrigeration measures dominate electric potential in the commercial sector across all scenarios.
- Recent guidance from the CPUC indicates that LED lighting becomes the standard practice baseline in 2019.[61] Savings in the forecast period come from lighting controls measures and, for some building types (small commercial), AR programs. However, the market quickly becomes saturated, showing a decrease of savings in the future. The significant reduction of lighting potential visually exaggerates the contributions of remaining end uses in all graphs.
- Commercial whole building potential contributes significantly to overall potential across all scenarios. Savings for whole buildings account for savings from anticipated future iterations of building codes. Commercial whole building potential is lower than in past studies because the potential was reduced to account for LEDs becoming standard practice in commercial lighting.
- Overall potential decreases over the forecast period. This is due to the model simulating an increasingly saturated market over time as more customers begin adopting efficient equipment.

[61] CPUC Resolution E-4952, October 11, 2018. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M225/K049/225049353.PDF

**Figure 4-31. Statewide Commercial Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Reference)**

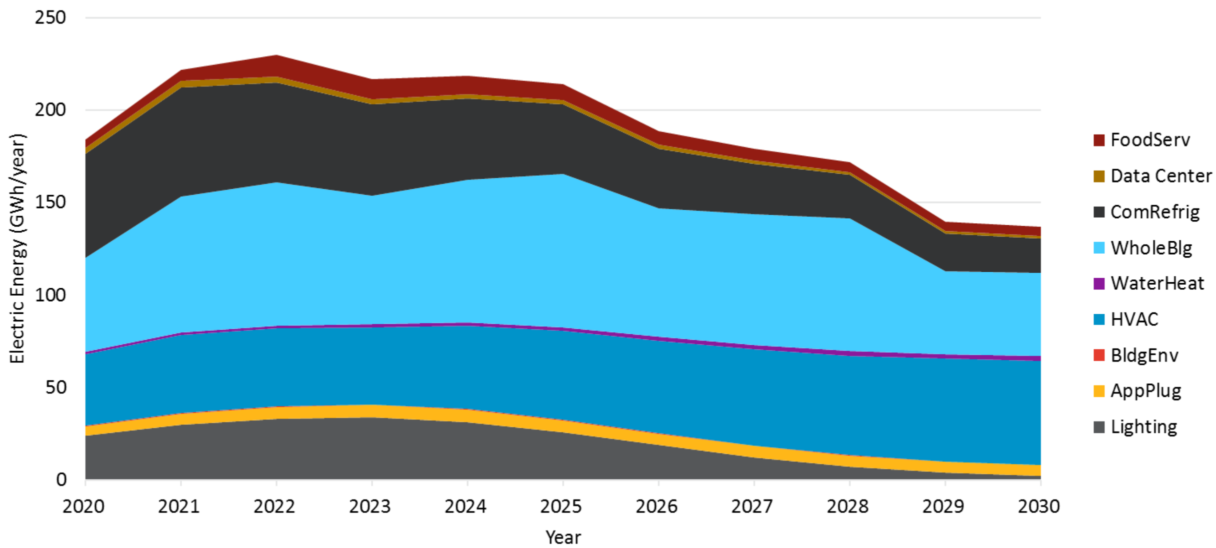



**Figure 4-32. Statewide Commercial Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 1)**

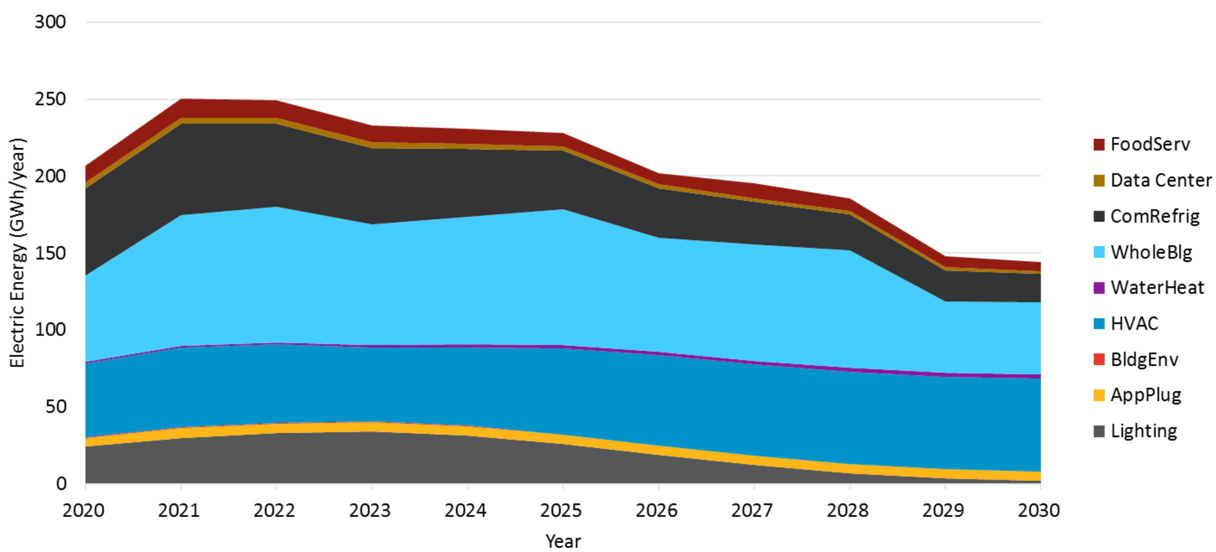


**Figure 4-33. Statewide Commercial Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 2)**

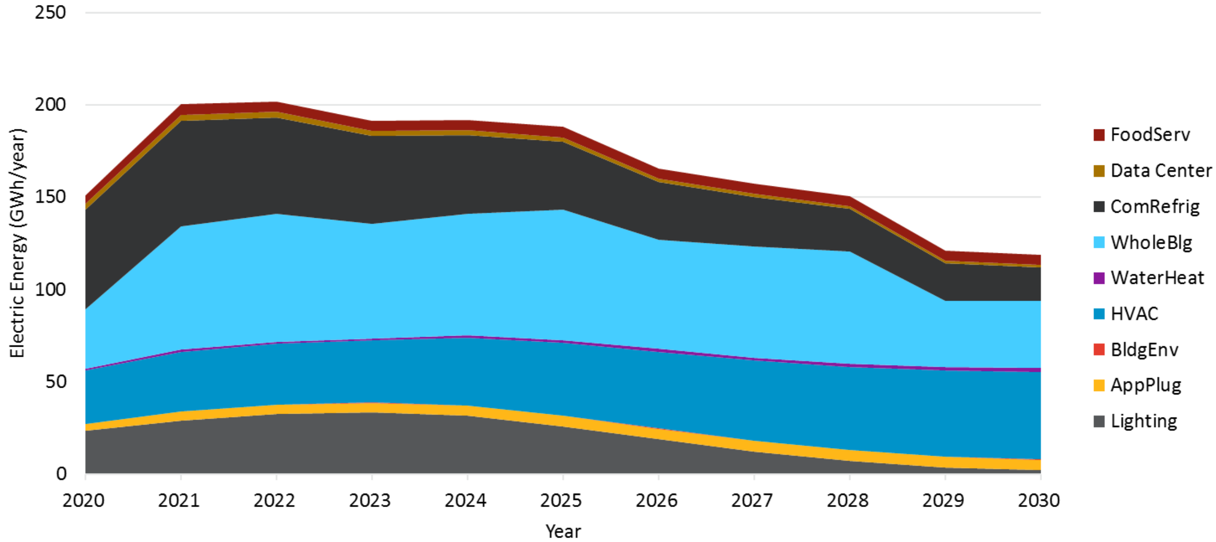



**Figure 4-34. Statewide Commercial Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 3)**

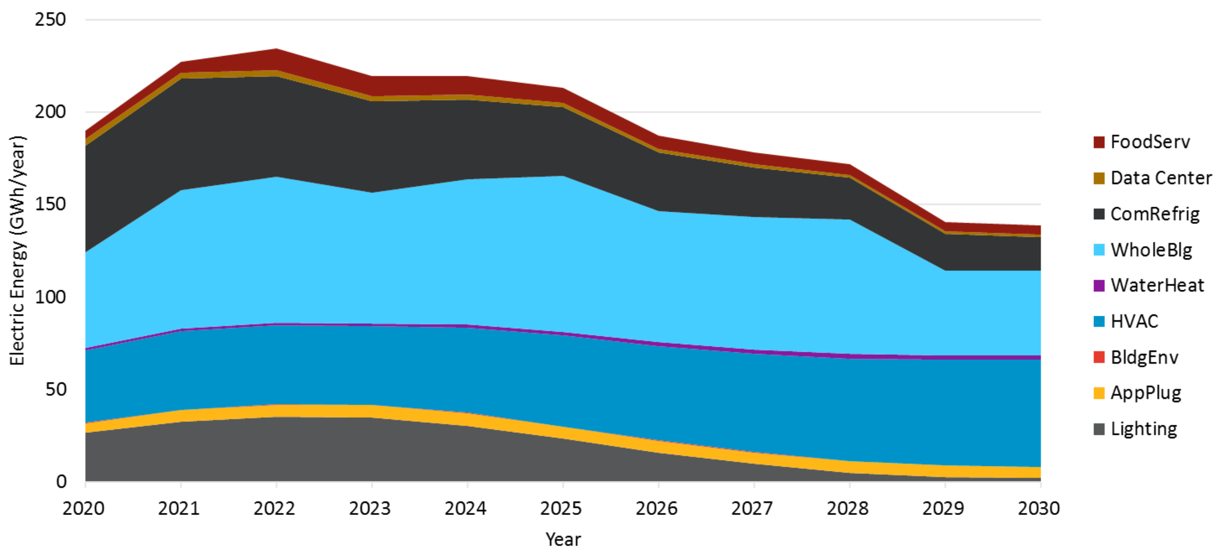


**Figure 4-35. Statewide Commercial Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 4)**

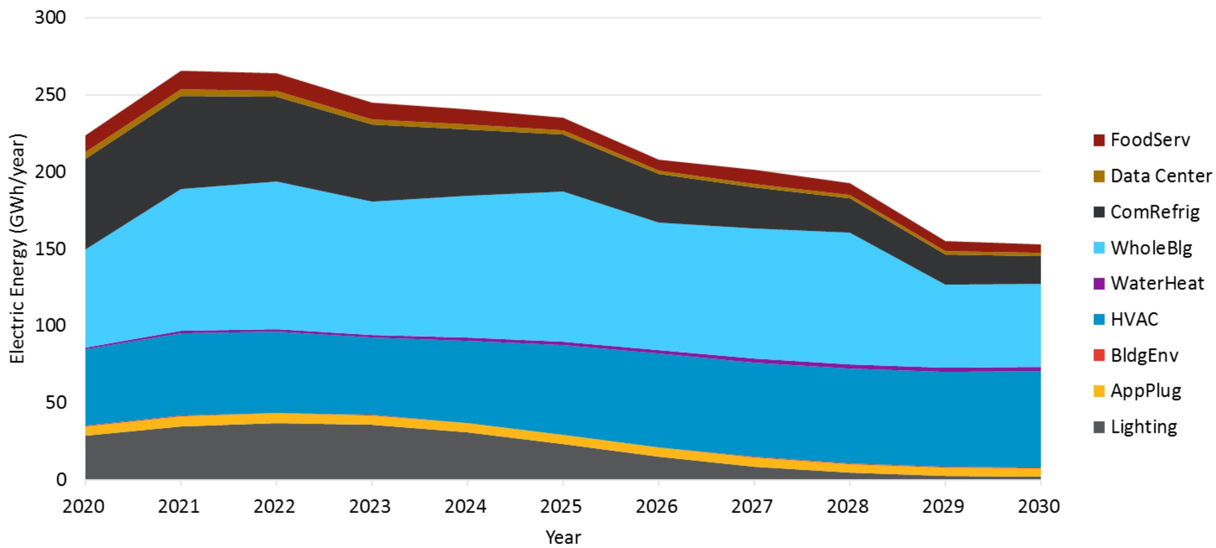



Figure 4-36 through Figure 4-40 show the breakdown of gas savings by end use in the commercial sector for each scenario. Key observations from these figures include the following:

- Among end-use categories that capture potential from discrete measures, food service and water heating dominate potential in the commercial sector, followed by HVAC measures across all scenarios. Unlike the residential sector, one or more HVAC measures is cost-effective under all scenarios throughout the forecast period.
- Commercial whole building potential also contributes to overall potential across all scenarios and is generally comparable to other end-use categories.
- Unlike electric potential, overall potential is relatively flat over the forecast period across all scenarios as most gas measures have long lifetimes and do not turn over as fast. As such, there continues to be opportunity for first-time adopters in the market, which does not saturate as fast.

**Figure 4-36. Statewide Commercial Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Reference)**

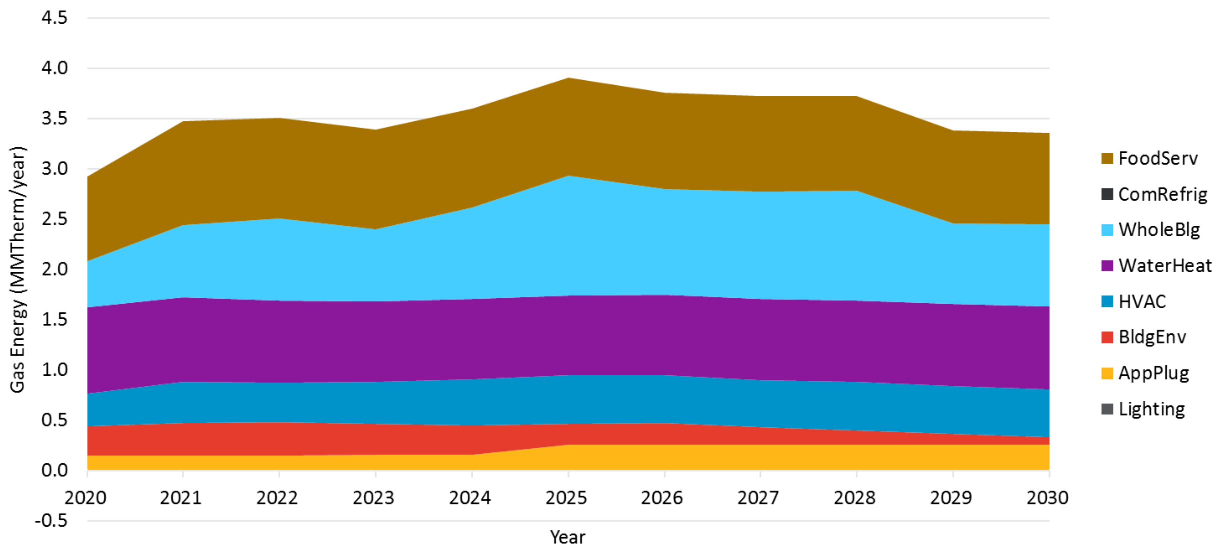



**Figure 4-37. Statewide Commercial Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 1)**

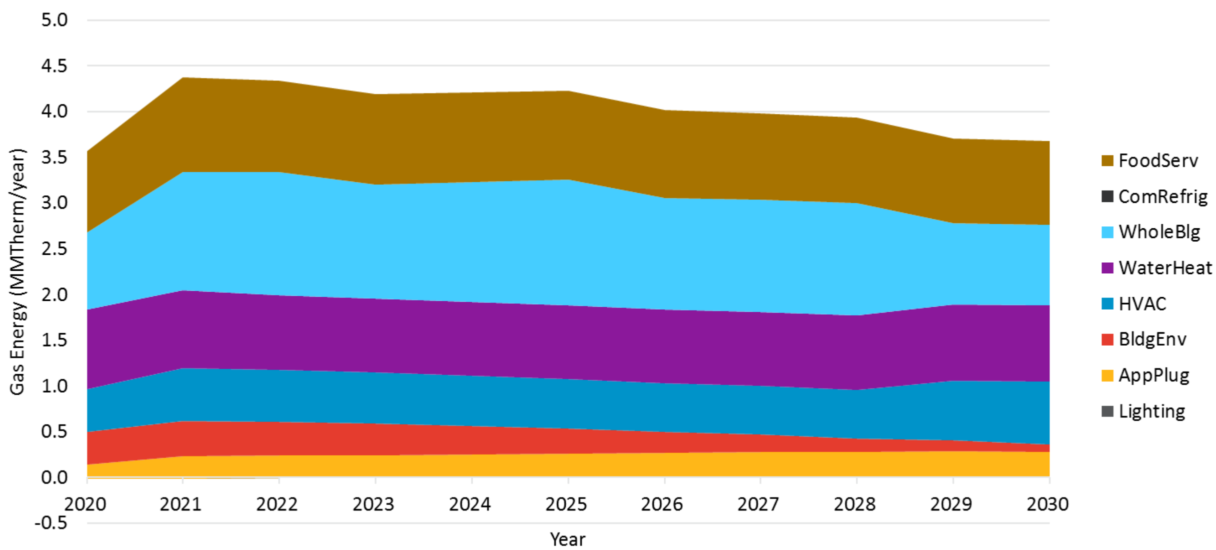


**Figure 4-38. Statewide Commercial Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 2)**

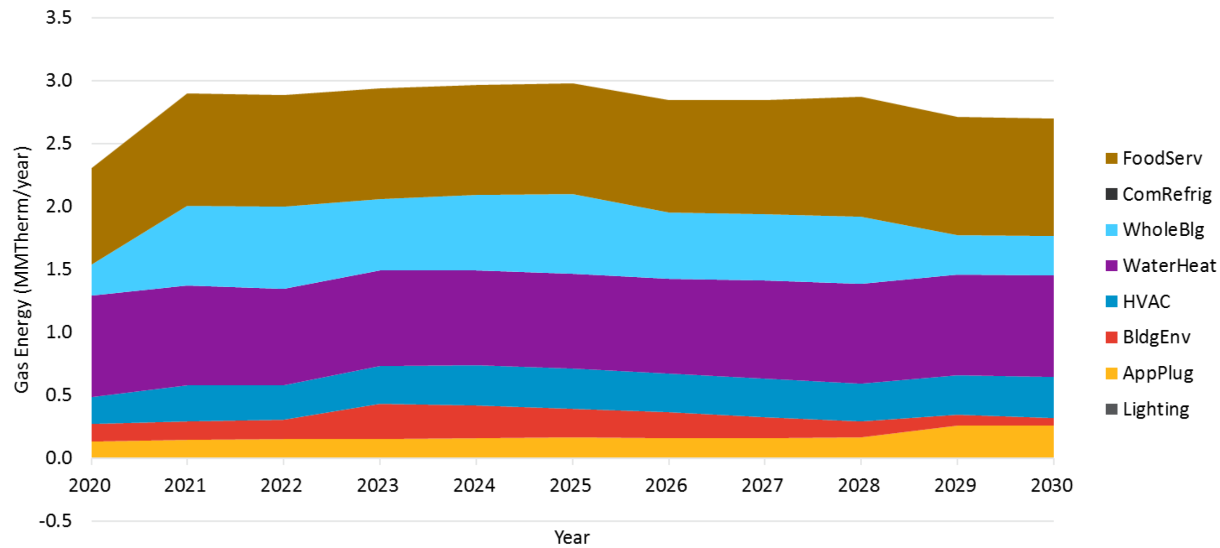



**Figure 4-39. Statewide Commercial Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 3)**

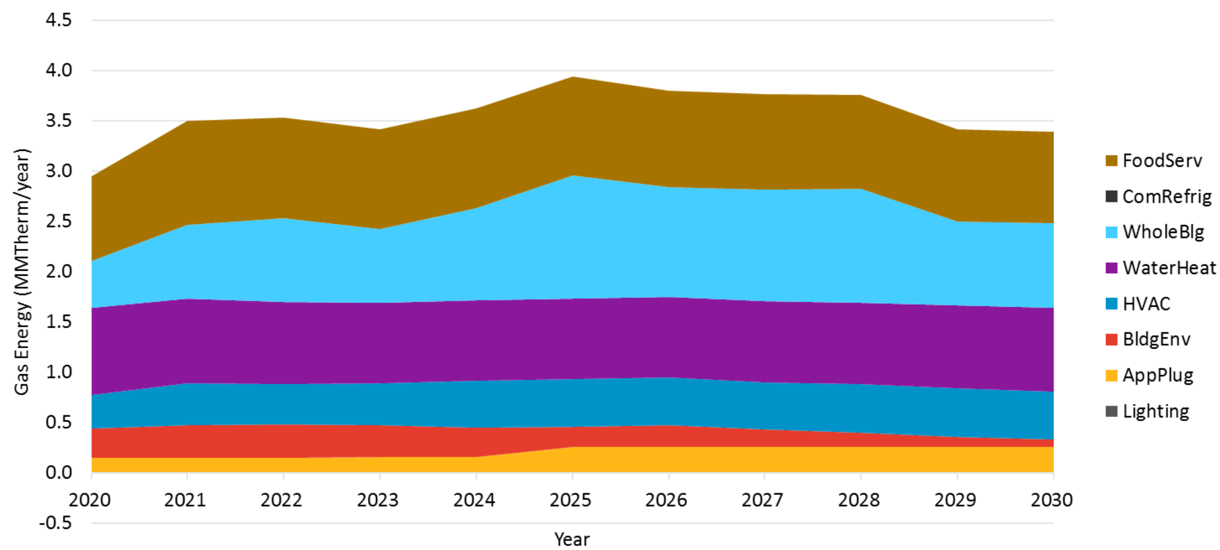
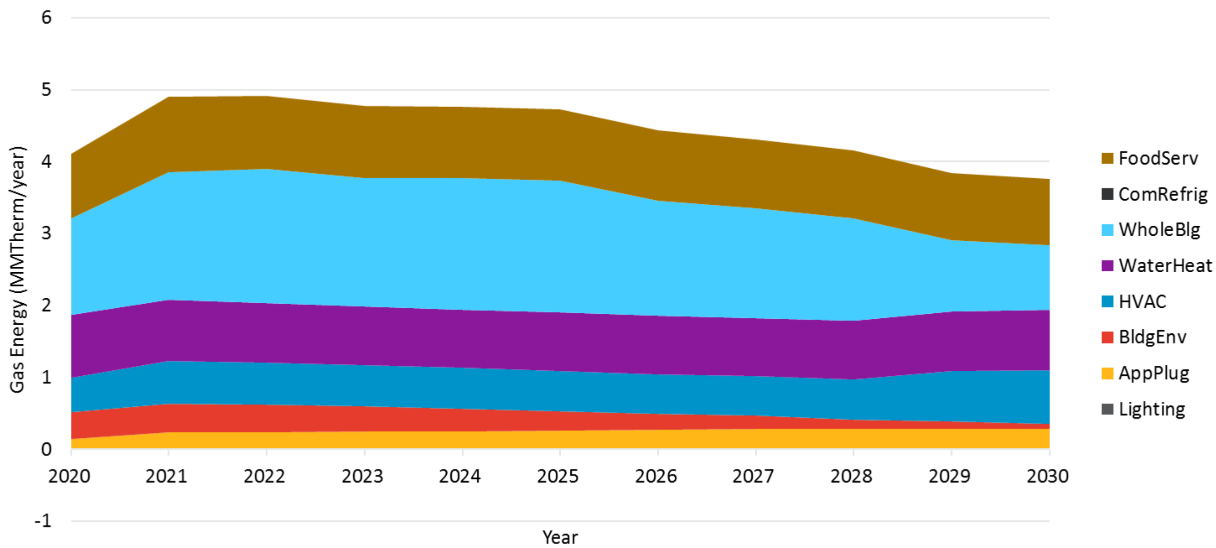


**Figure 4-40. Statewide Commercial Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 4)**




### *4.1.3.3 AIMS Rebate Programs*

Figure 4-41 through Figure 4-45 show the breakdown of electric savings by end use in the AIMS sectors for each scenario. Key observations from these graphs are:

- Among end-use categories that capture potential from discrete measures that produce deemed savings, whole building dominates electric potential in the agriculture and industrial sectors, followed by machine drive and lighting measures across all scenarios.
- Recent guidance from the CPUC indicates that LED lighting becomes the standard practice baseline in 2019.[62] Savings in the forecast period come from lighting controls measures and, for some building types (small commercial), AR programs. However, the market quickly becomes saturated, showing a decrease of savings in the future. The significant reduction of lighting potential visually exaggerates the contributions of remaining end uses in all graphs.
- The whole building end-use category represents potential from generic custom measures and emerging technologies in the agriculture and industrial sectors. Potential from these measures contributes significantly to the agriculture and industrial sectors across all scenarios and is expected to increase over time. These measures are tagged into the whole building end use because it represents a broad array of opportunities across all end uses.
- The mining sector, which is made up of oil and gas extraction equipment, contributes minimally to overall potential across all scenarios.
- Only one street lighting measure, advanced lighting controls, contributes a steady amount of potential across the forecast period across all scenarios.

[62] CPUC Resolution E-4952, October 11, 2018. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M225/K049/225049353.PDF

- Potential from individual technologies in the agriculture and industrial sectors ramps down over the forecast period across all scenarios. To align with historic program activity and the characteristics of the market, the calibration process saw a significant majority of the potential being realized between 2013 and 2018. Thus, the forecast years reflect less opportunity and an increasingly saturated market over time. This decrease in potential from deemed savings is somewhat made up for toward the end of the forecast period by increased potential from emerging technologies.

**Figure 4-41. Statewide AIMS Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Reference)**

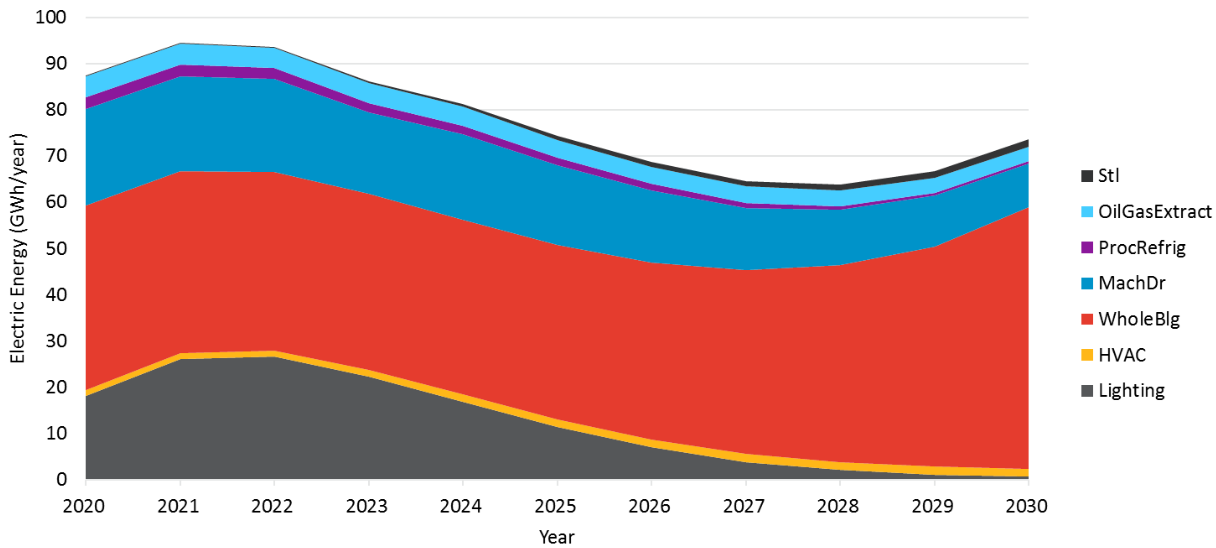



**Figure 4-42. Statewide AIMS Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 1)**

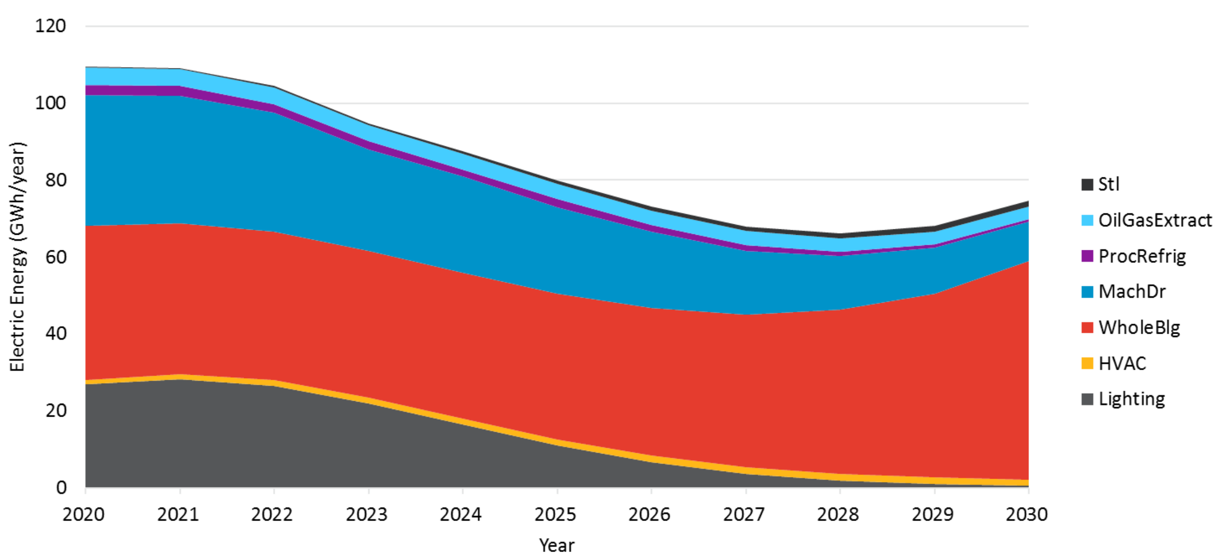


**Figure 4-43. Statewide AIMS Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 2)**

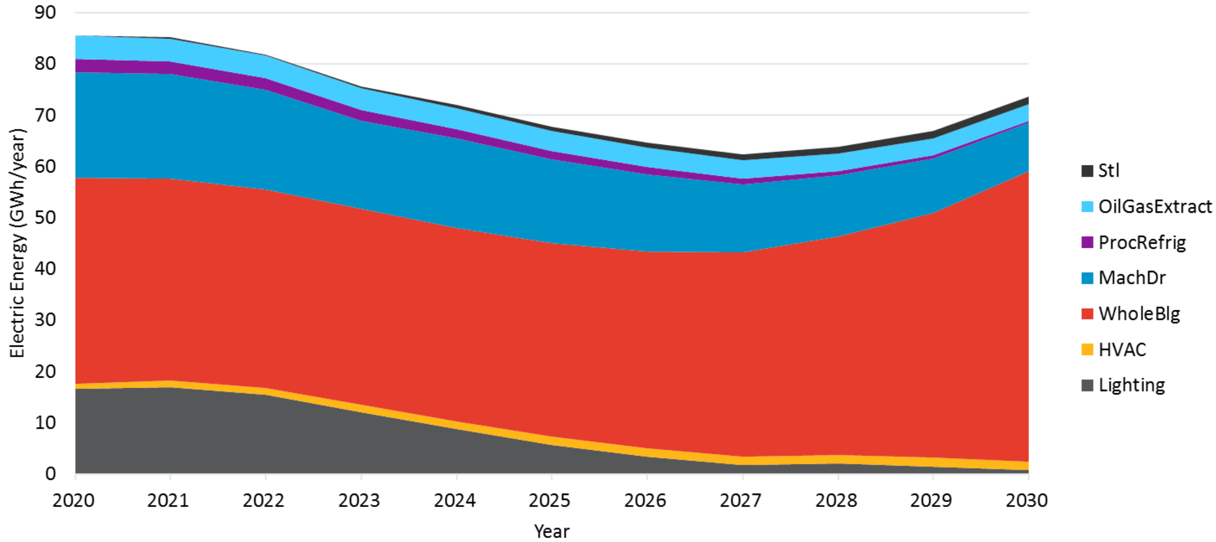



**Figure 4-44. Statewide AIMS Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 3)**

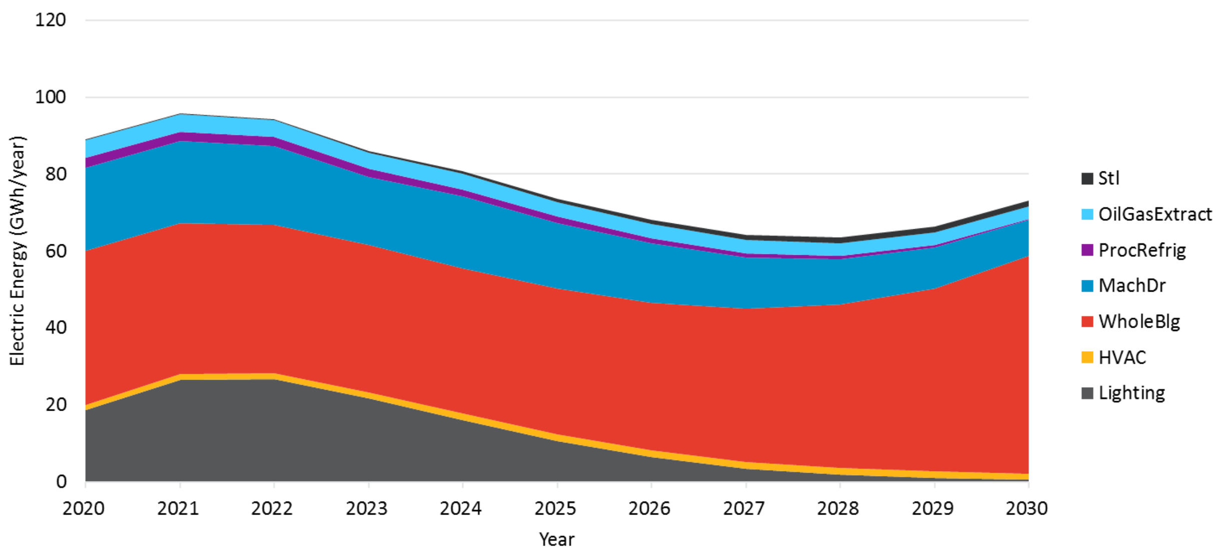


**Figure 4-45. Statewide AIMS Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 4)**

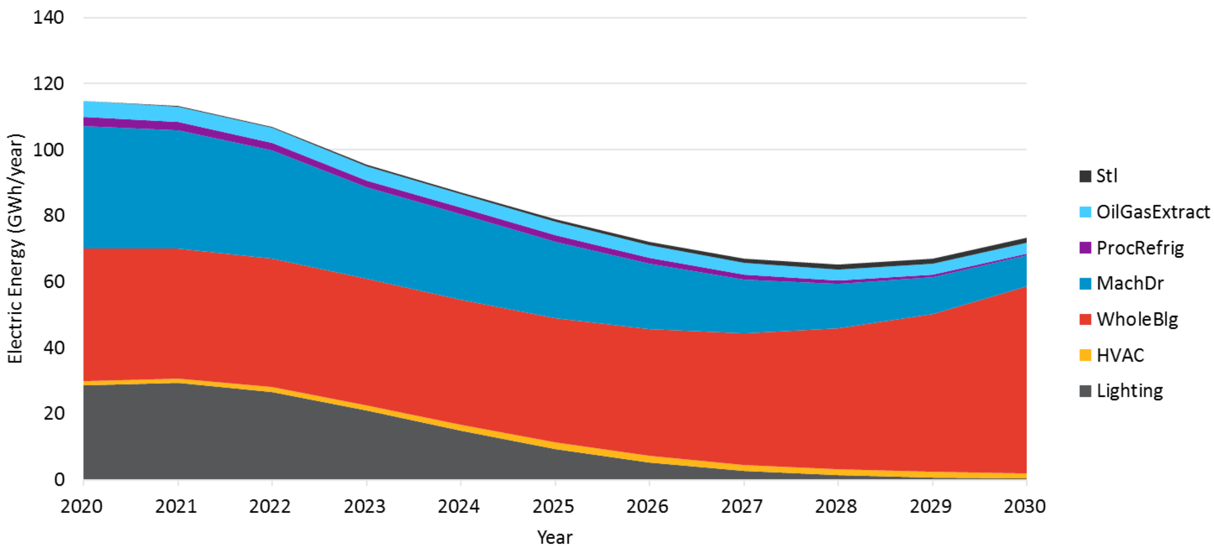



Figure 4-46 through Figure 4-50 show the breakdown of gas savings by end use in the AIMS sectors for each scenario. Key observations from these figures include the following:

- The whole building end-use category represents potential from generic custom measures and emerging technologies in the agriculture and industrial sectors. Potential from these measures contributes significantly to the agriculture and industrial sectors and is expected to increase over time across all scenarios.
- Among end-use categories that capture potential from discrete measures that produce deemed savings, process heat dominates gas potential in the agriculture and industrial sectors, followed by HVAC across all scenarios.
- The variation and spikes in potential for process heating is a result of different C-E threshold screens across the five scenarios. Process heating measures become cost-effective in different years of the forecast depending on the threshold used. For example, in Alternative 2, a TRC threshold of 1.25 is used, delaying the introduction of significant cost-effective potential until 2026, whereas Alternative 1 (using a threshold of 0.85) shows significant cost-effective potential starting in 2020.

**Figure 4-46. Statewide AIMS Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Reference)**

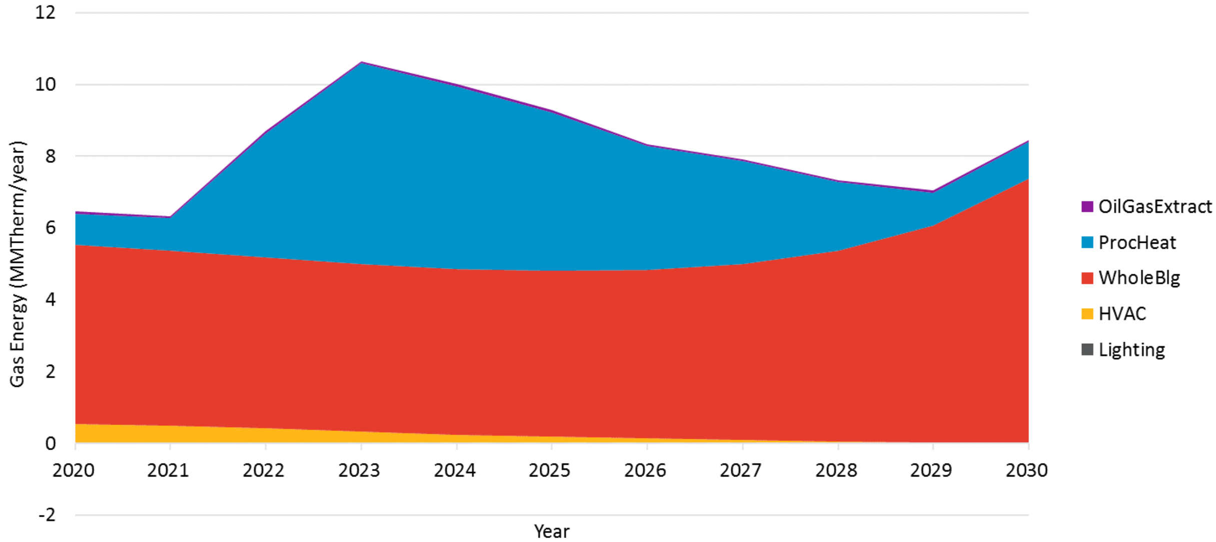



**Figure 4-47. Statewide AIMS Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 1)**

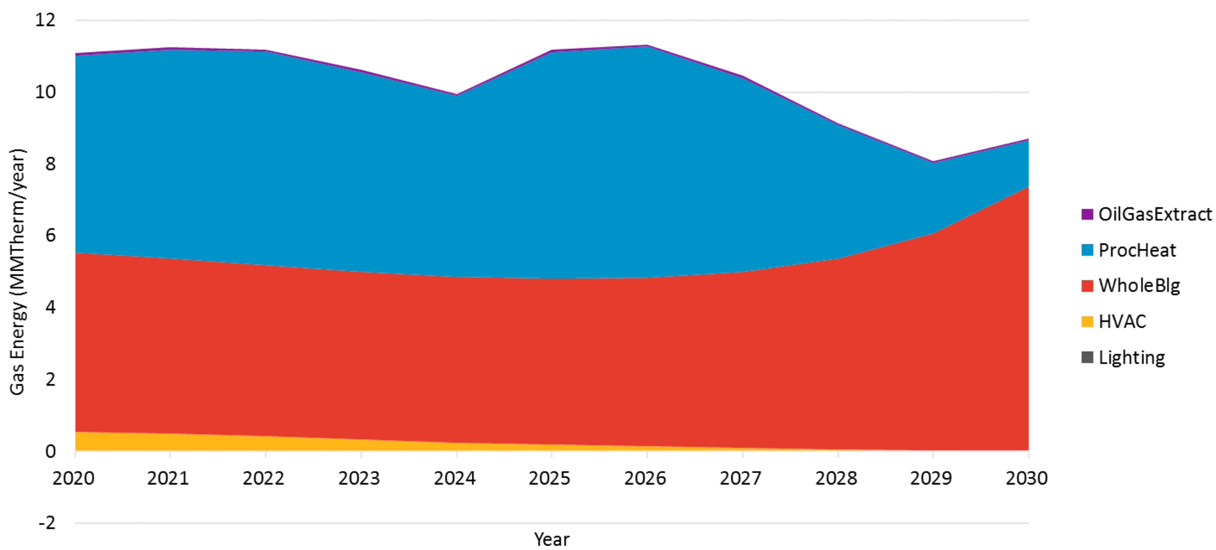


**Figure 4-48. Statewide AIMS Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 2)**

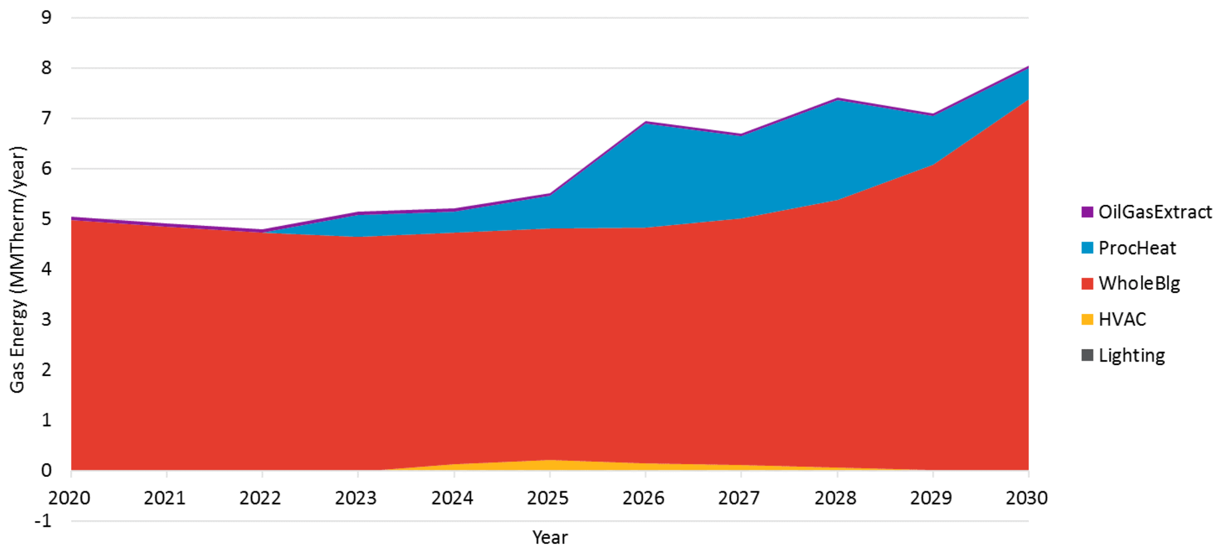



**Figure 4-49. Statewide AIMS Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 3)**

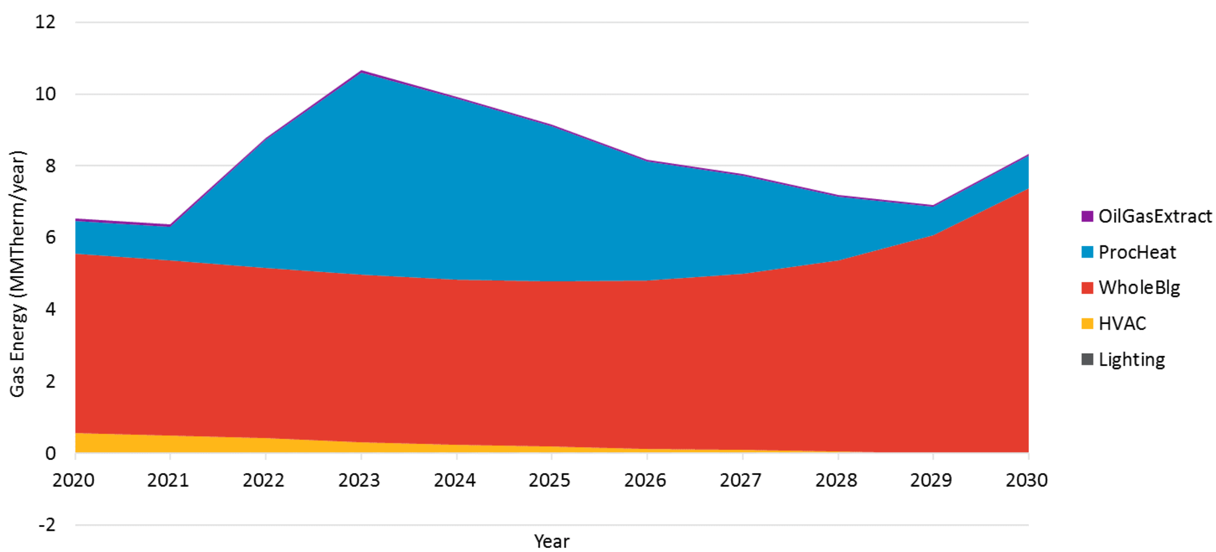
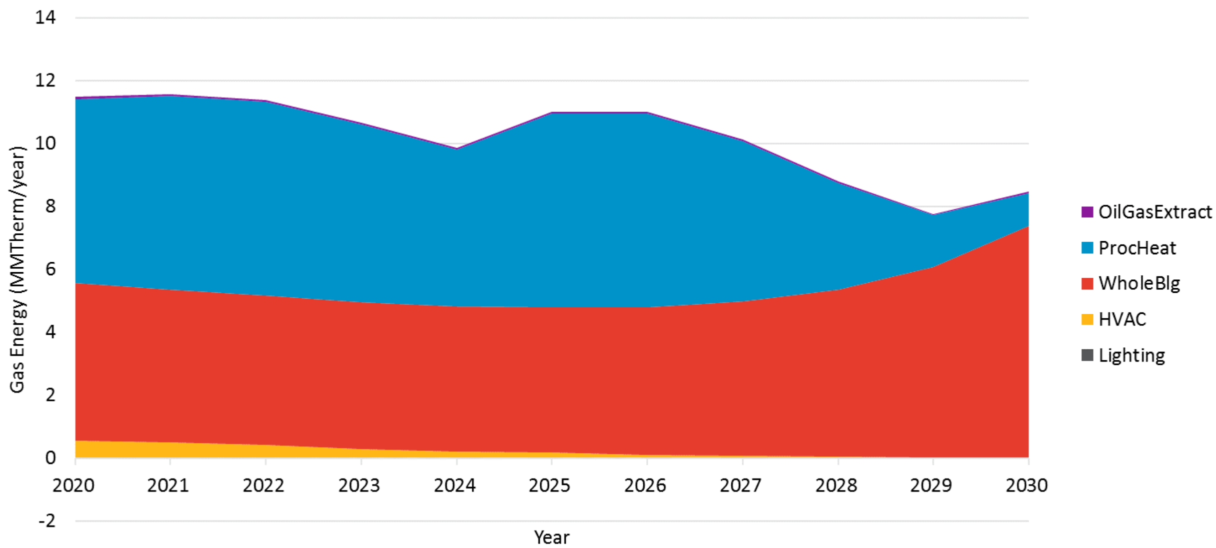


**Figure 4-50. Statewide AIMS Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 4)**




#### *4.1.3.4 Below Code Potential*

Figure 4-51 through Figure 4-55 show the breakdown of electric below code potential by end use across all sectors for each scenario. These savings are captured through AR decisions in the model prompted by the availability of rebates for upgrading existing below code equipment. The Navigant team assumes that these rebates will be available starting in 2018 in the model. HVAC and water heating make up the vast majority of below code potential for both electric and gas fuel types.

**Figure 4-51. Statewide Below Code Electric Potential by End Use for All Sectors (Reference)**

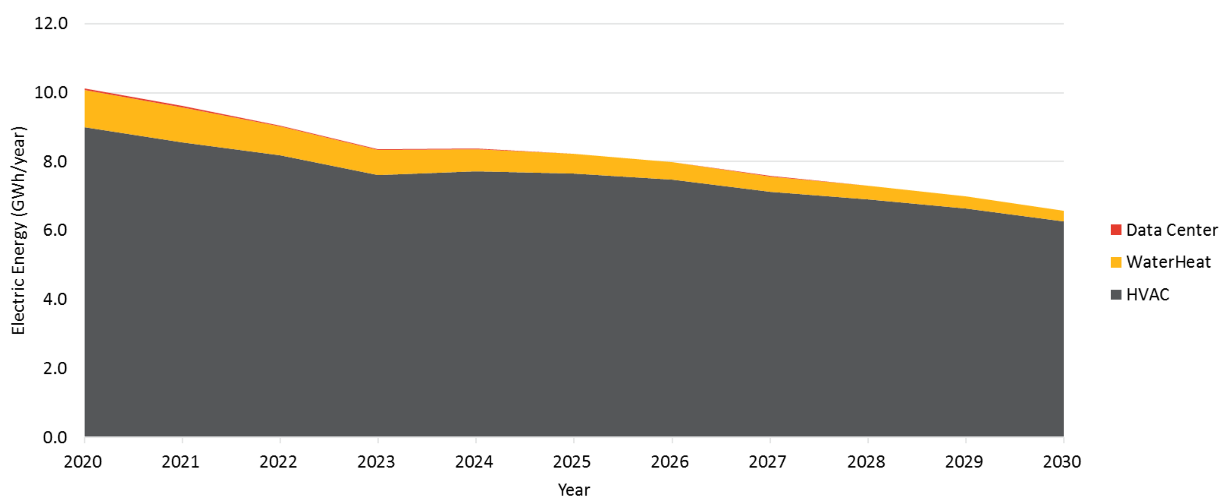


**Figure 4-52. Statewide Below Code Electric Potential by End Use for All Sectors (Alternative 1)**

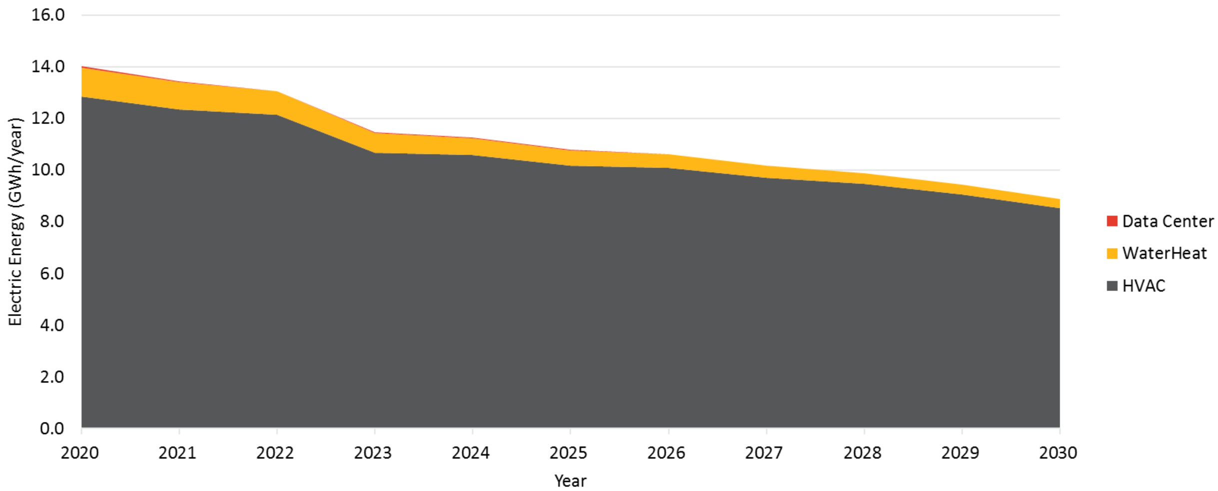



**Figure 4-53. Statewide Below Code Electric Potential by End Use for All Sectors (Alternative 2)**

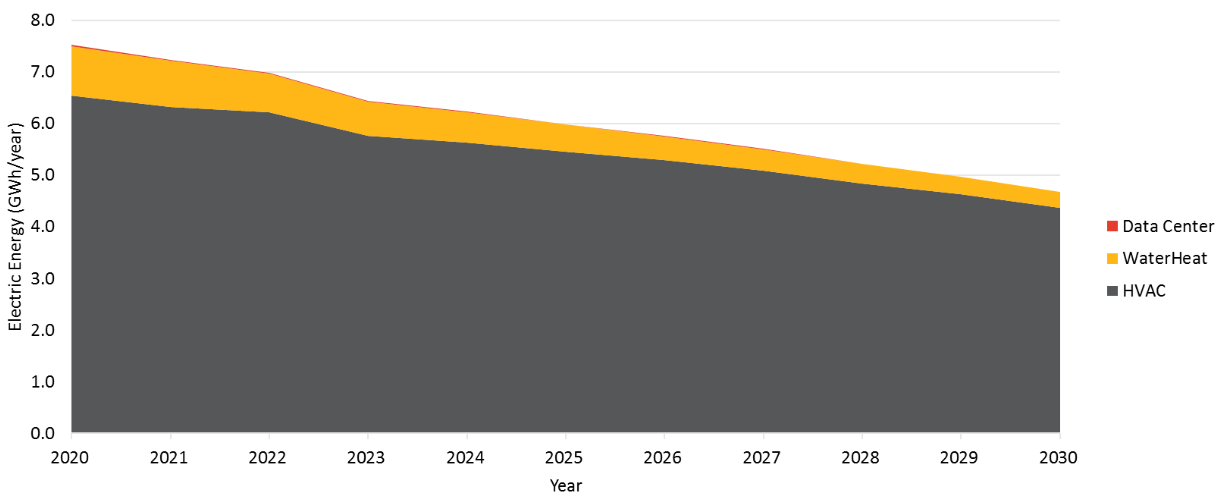


**Figure 4-54. Statewide Below Code Electric Potential by End Use for All Sectors (Alternative 3)**

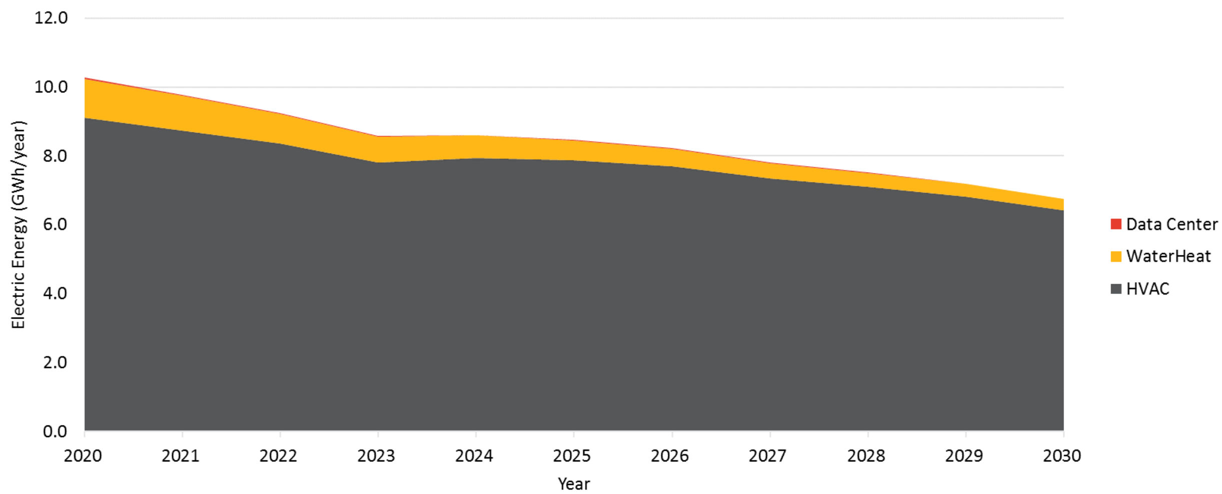



**Figure 4-55. Statewide Below Code Electric Potential by End Use for All Sectors (Alternative 4)**

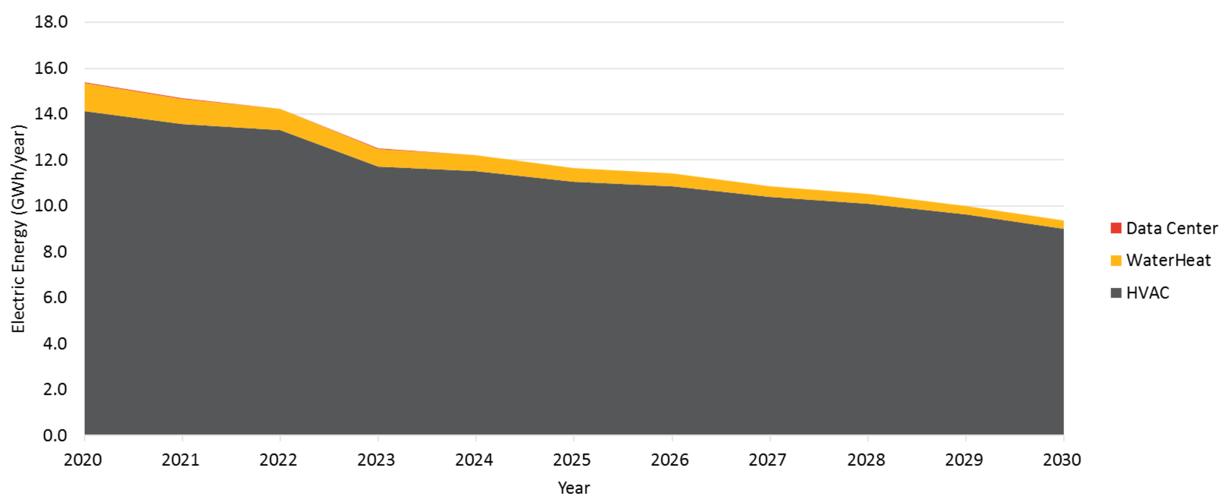



Figure 4-56 and Figure 4-60 show the breakdown of gas below code potential by end use across all sectors.

**Figure 4-56. Statewide Below Code Gas Potential by End Use for All Sectors (Reference)**

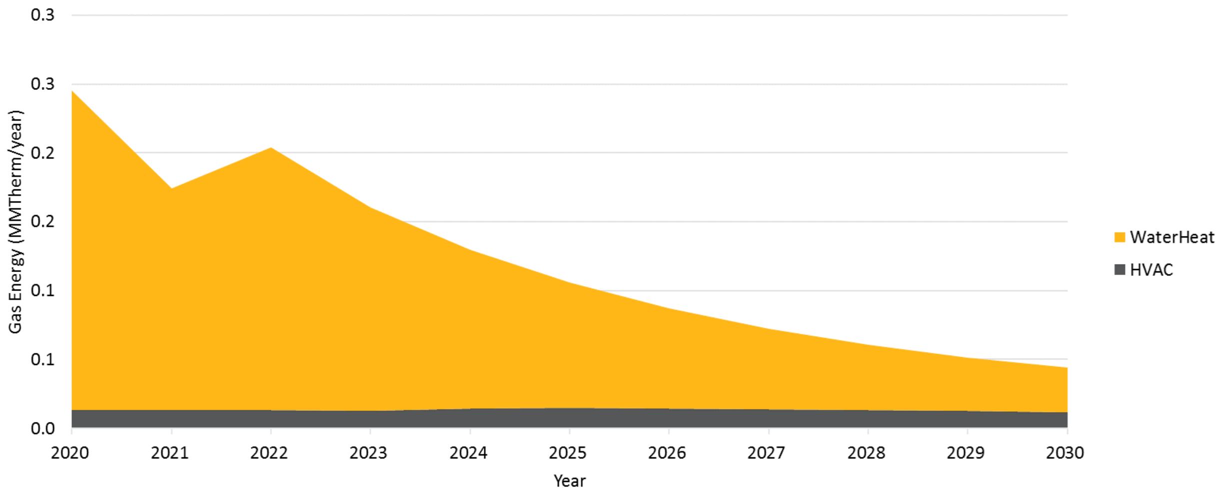



**Figure 4-57. Statewide Below Code Gas Potential by End Use for All Sectors (Alternative 1)**

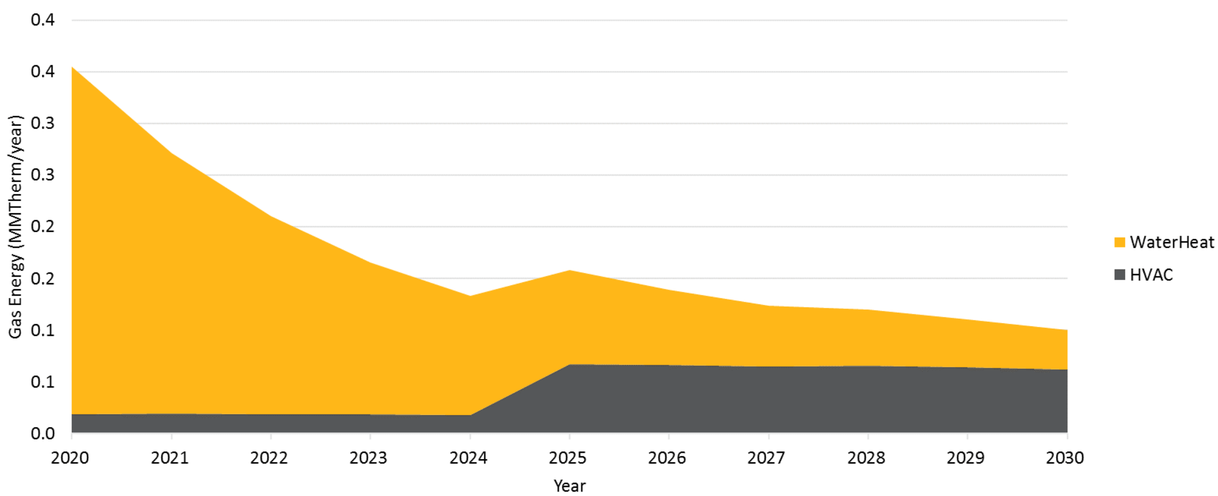


**Figure 4-58. Statewide Below Code Gas Potential by End Use for All Sectors (Alternative 2)**

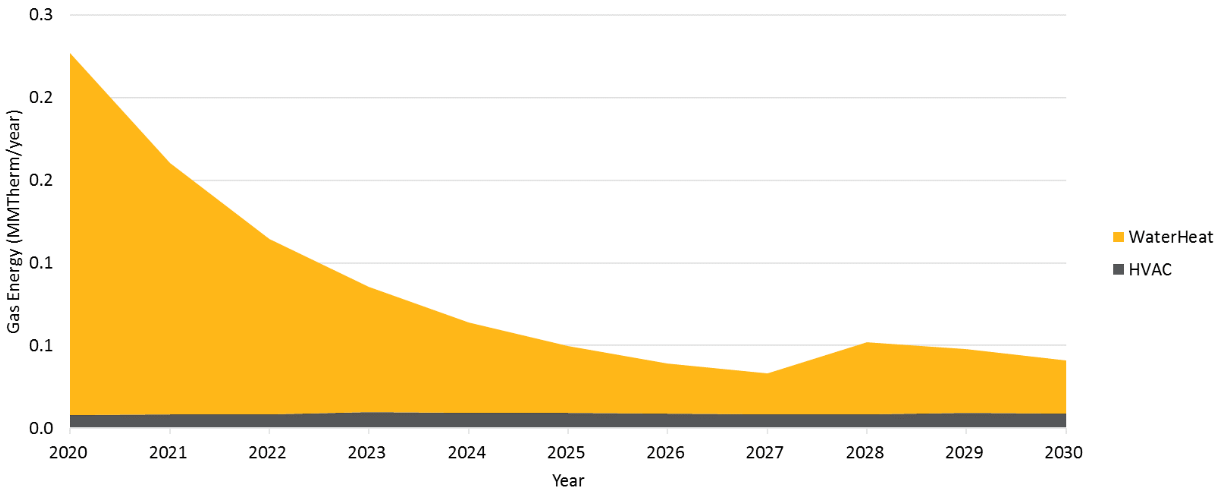



**Figure 4-59. Statewide Below Code Gas Potential by End Use for All Sectors (Alternative 3)**

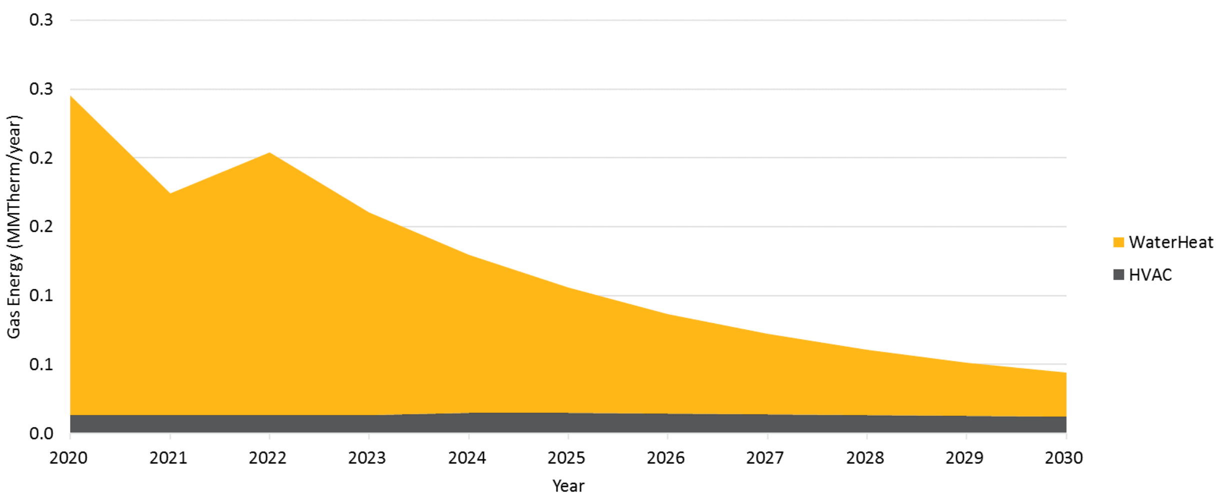
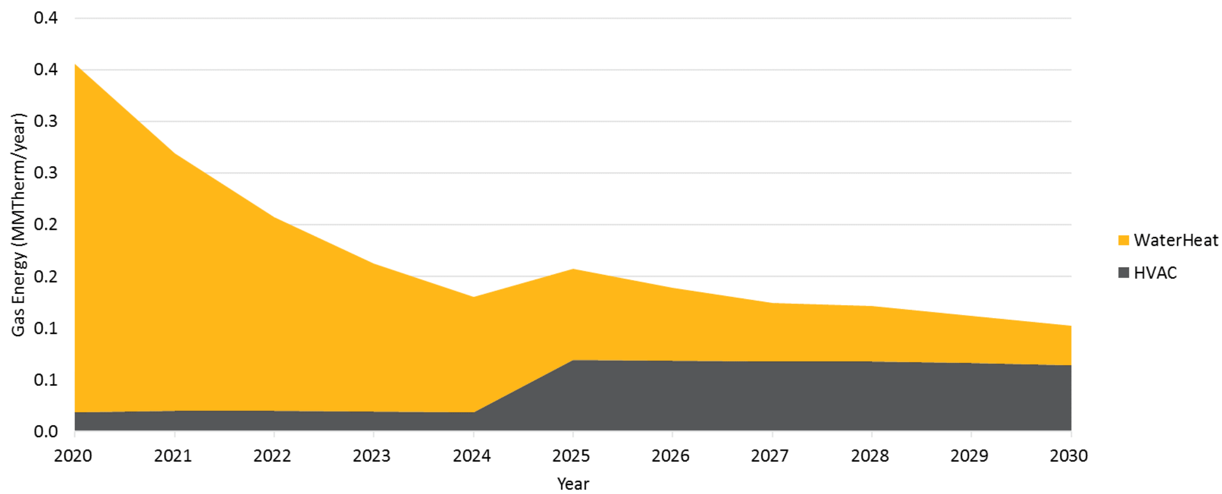


**Figure 4-60. Statewide Below Code Gas Potential by End Use for All Sectors (Alternative 4)**




### *4.1.3.5 Rebate Program Cost-Effectiveness*

The Navigant team calculated the cost-effectiveness (TRC, PAC, and RIM)[63] for the portfolio of forecasted measures under the equipment rebate programs for each IOU and each scenario. Several caveats are noted on these results:

- These results account for benefits and costs from rebated measures that contribute to equipment savings but exclude low income, C&S savings, BROs, and industrial/agricultural generic custom and emerging technologies.
- Results exclude non-resource program costs which are typically accounted for in a portfolio-level C-E assessment.
- Program non-incentive costs are estimated based on past program years; these could vary in the future.

Figure 4-61 through Figure 4-64 show the TRC for each IOU across each scenario. Alternative 2 generally has the highest TRC given it uses the most restrictive TRC threshold for measures (1.25), while Alternatives 1 and 4 have the lowest TRC (use the least restrictive threshold). Overall, all scenarios for all utilities show a TRC greater than 1.0. However, the following scenarios/utilities fall short of a 1.25 TRC:

- PG&E for Alternate 1 and Alternate 4
- SDG&E for Alternate 1 and Alternate 4

[63] TRC - Total Resource Cost. PAC - Program Administrator Cost. RIM - Ratepayer Impact Measure.

**Figure 4-61. PG&E – TRC of Forecasted Rebate Program Scenarios**

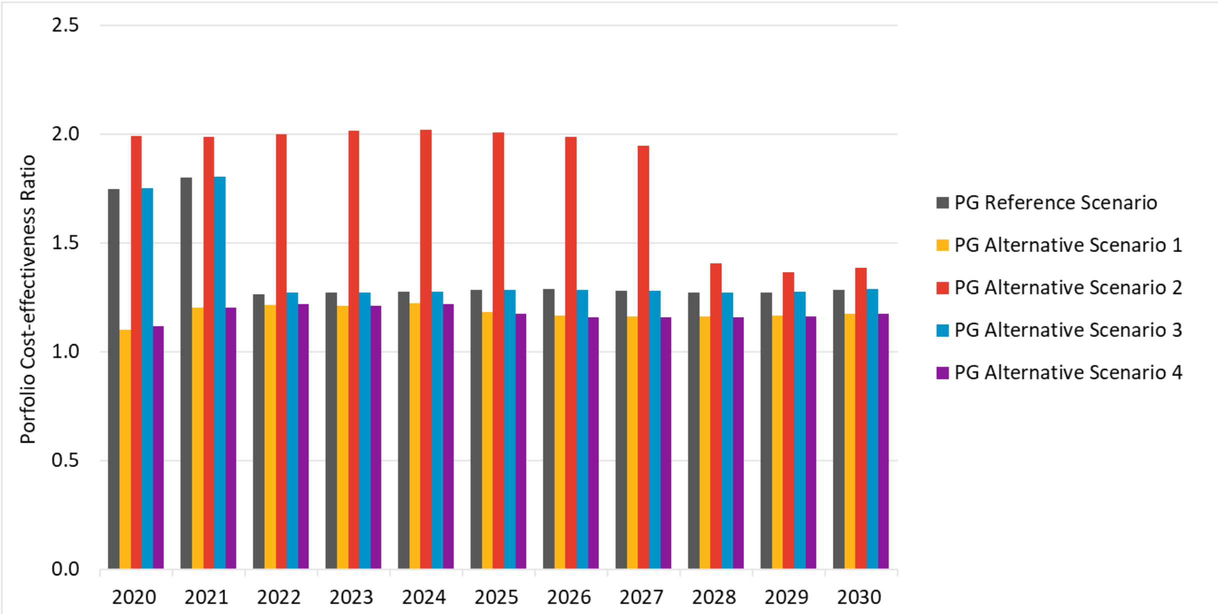



**Figure 4-62. SCE – TRC of Forecasted Rebate Program Scenarios**

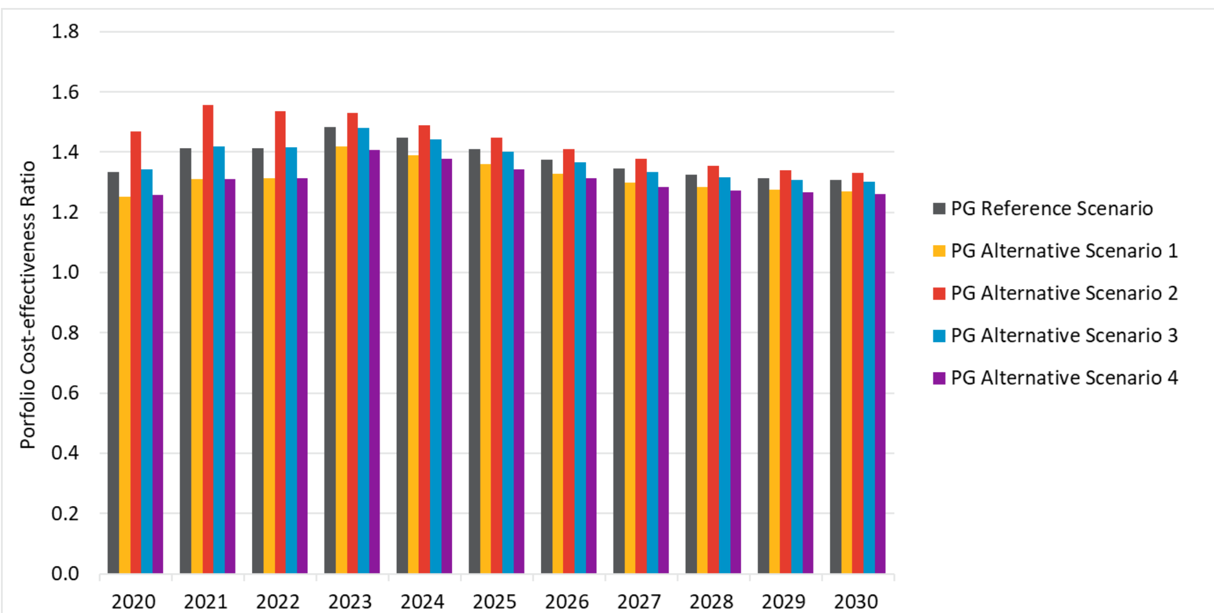


**Figure 4-63. SCG – TRC of Forecasted Rebate Program Scenarios**

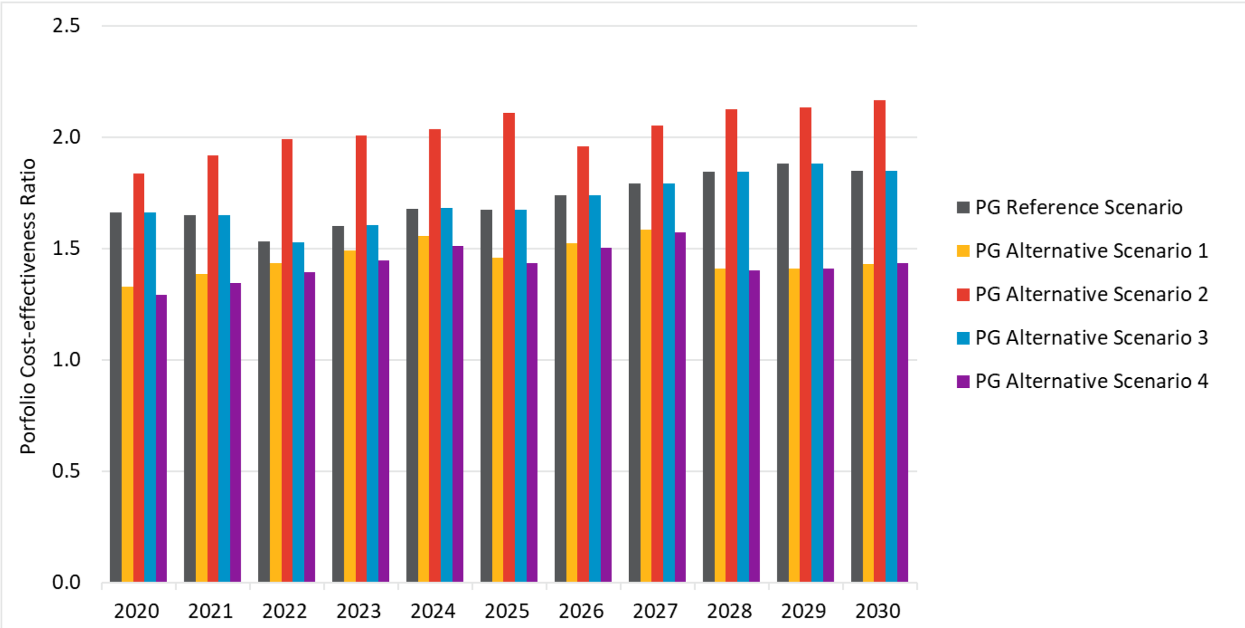
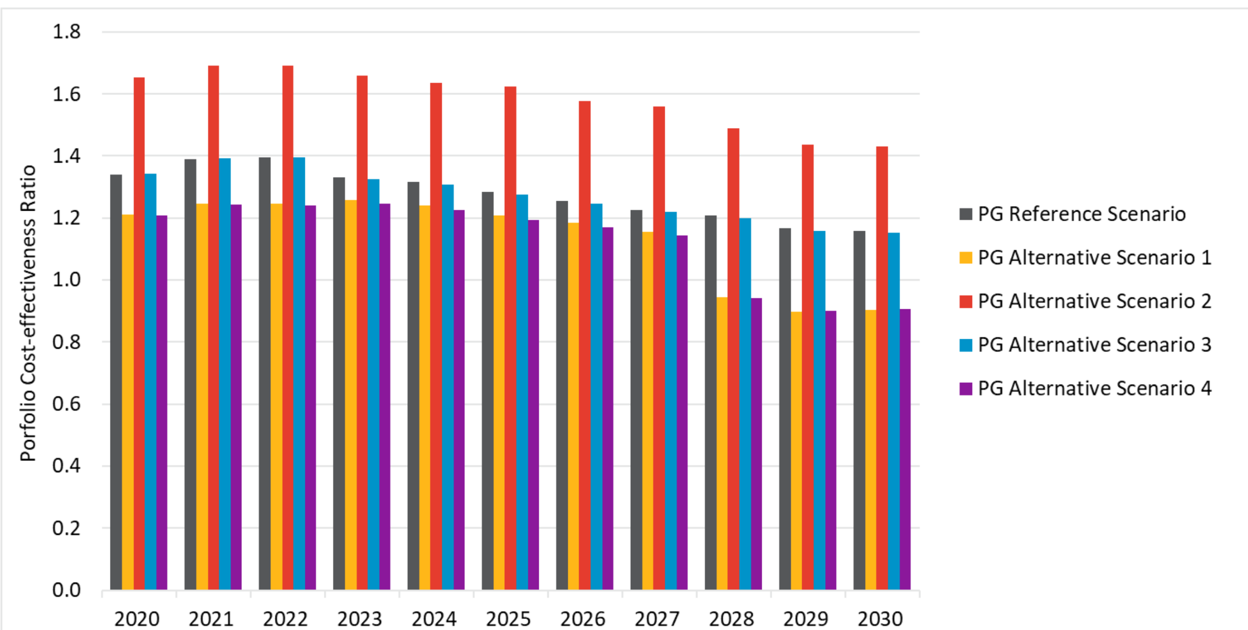



**Figure 4-64. SDG&E – TRC of Forecasted Rebate Program Scenarios**




### *4.1.4 BROs Scenario Results*

This section presents incremental savings and program spending on BROs interventions under the reference and aggressive scenarios. The reference case includes only programs proven to be cost-effective through the TRC test screen, while the aggressive case includes all BROs programs characterized and assumes more aggressive adoption rates due to ramped up program delivery approaches relative to the reference case. Additional versions of figures appearing in this section for each IOU and including peak demand savings can be found in the results viewer.

Similar to 2017 Study results, the reference scenario is led by savings from HERs, as illustrated in Figure 4-65 and Figure 4-66. As such, program spending is also estimated to be led by HERs (Figure 4-67). HERs is one of the largest and most well studied existing interventions with reliable California data upon which to base a forecast.

Web-based, real-time feedback, BIEMS, SEM, and the UAT also represent the highest impact interventions after HERs. Savings from all interventions increase over time as the Navigant team expects enrollment in programs to gradually increase. Additional details about penetration rates can be found in Appendix C.

**Figure 4-65. BROs Electric Savings – Reference Scenario**

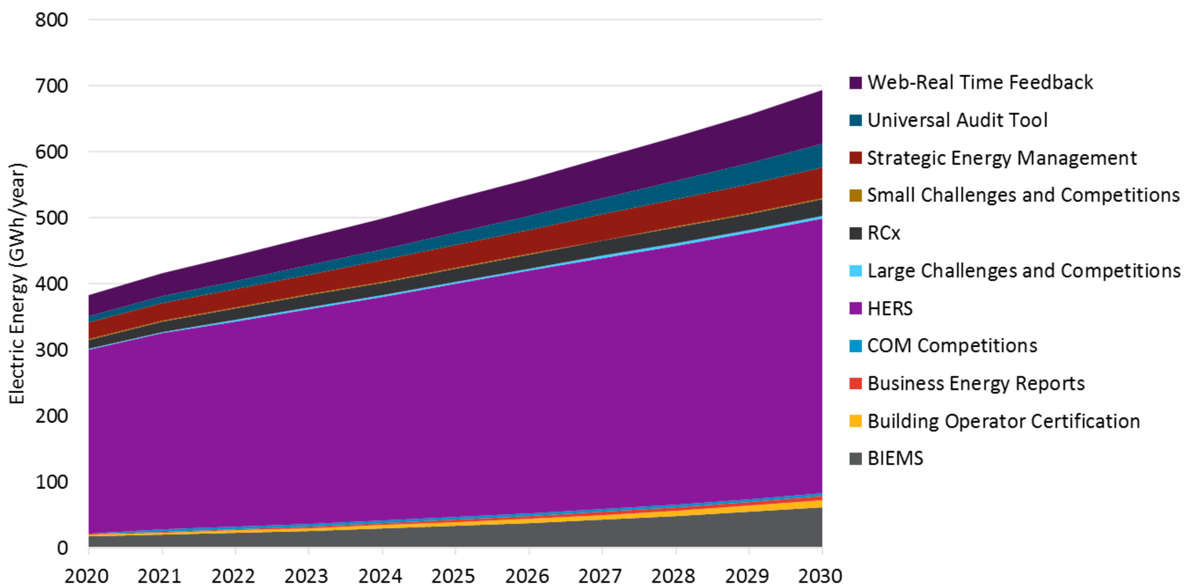


**Figure 4-66. BROs Gas Savings – Reference Scenario**

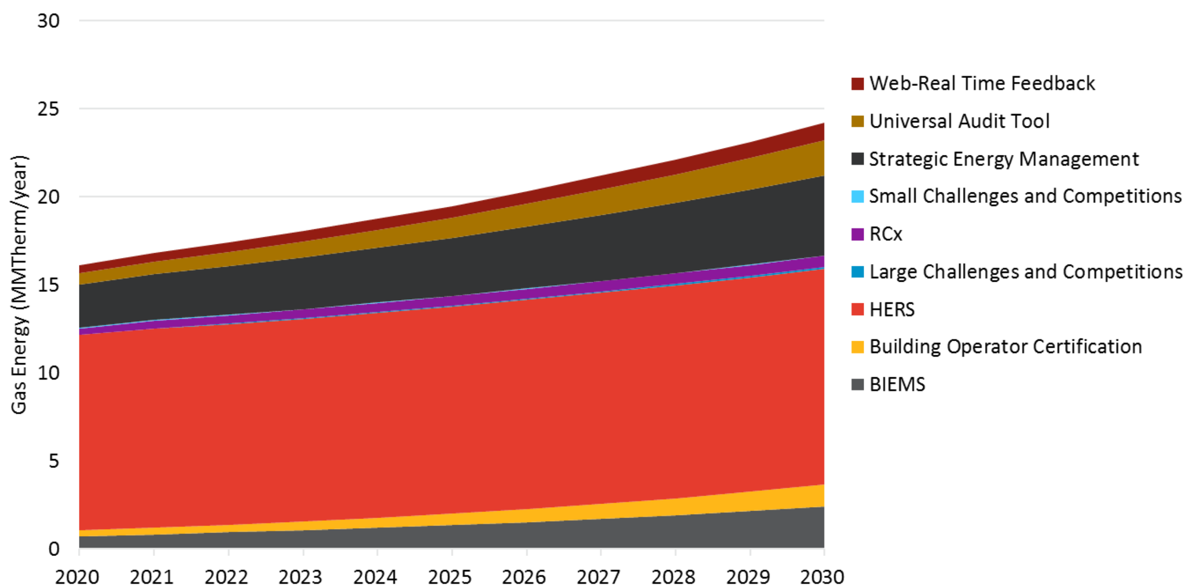
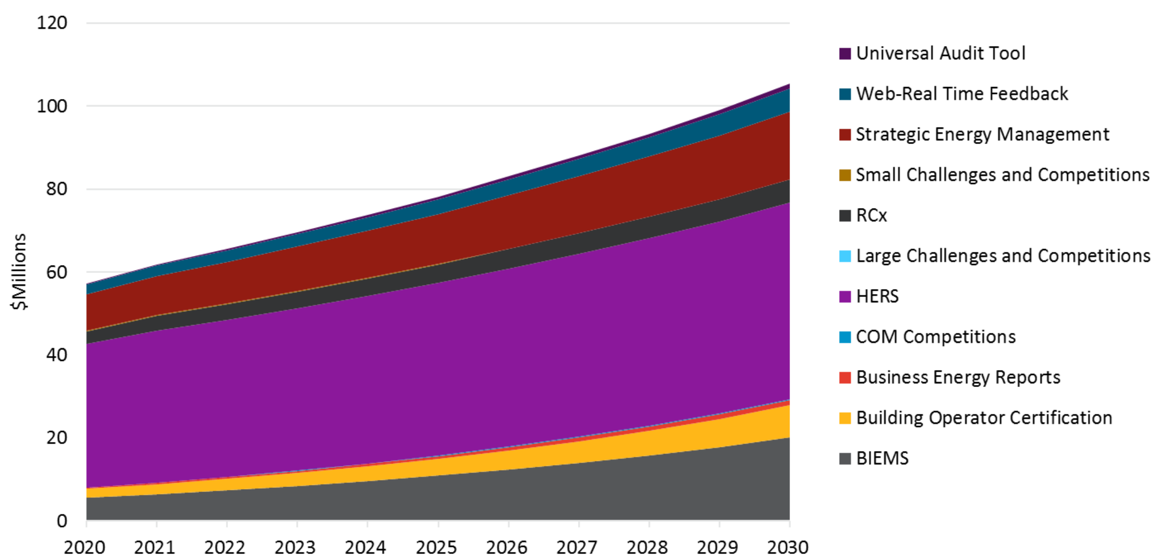



**Figure 4-67. BROs Program Spending – Reference Scenario**




The aggressive scenario still shows a large portion of savings originating from HERs through the forecast period (Figure 4-68 and Figure 4-69). The five highest impact interventions after HERs programs are BIEMS, web-based real-time feedback, the UAT, building benchmarking, and SEM, which combine for 92% of overall BROs savings forecast in 2030. The aggressive scenario contains savings from in-home displays and building benchmarking, while the reference scenario left these measure out due to low cost-effectiveness and possible ineligibility of savings[64], respectively. Savings and spending (Figure 4-70) in the aggressive scenario are just short of a doubling of the reference scenario.

**Figure 4-68. BROs Electric Savings – Aggressive Scenario**

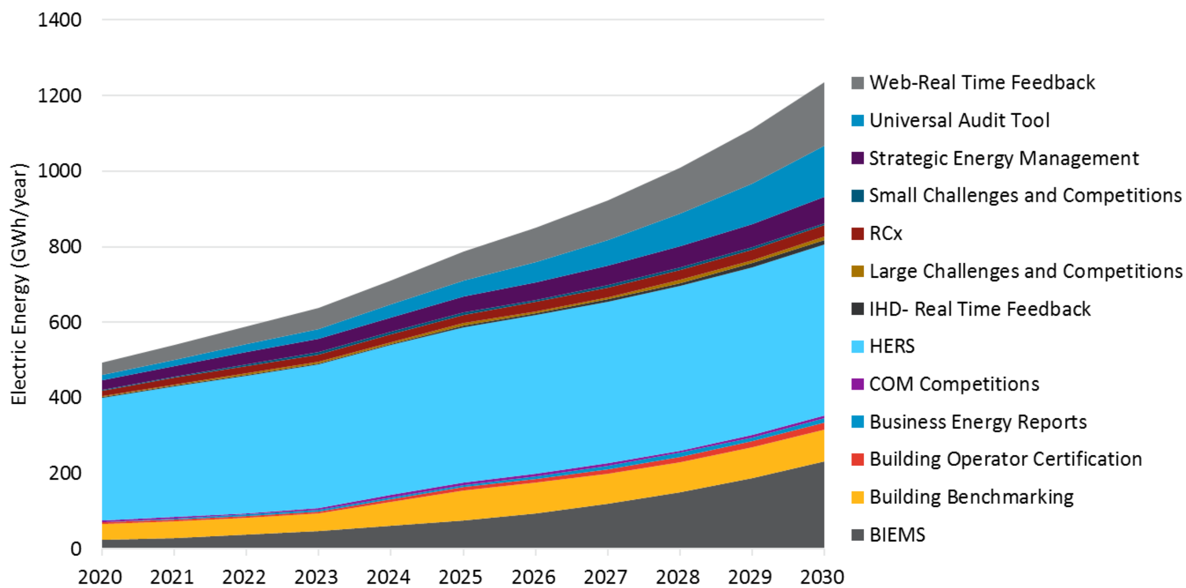
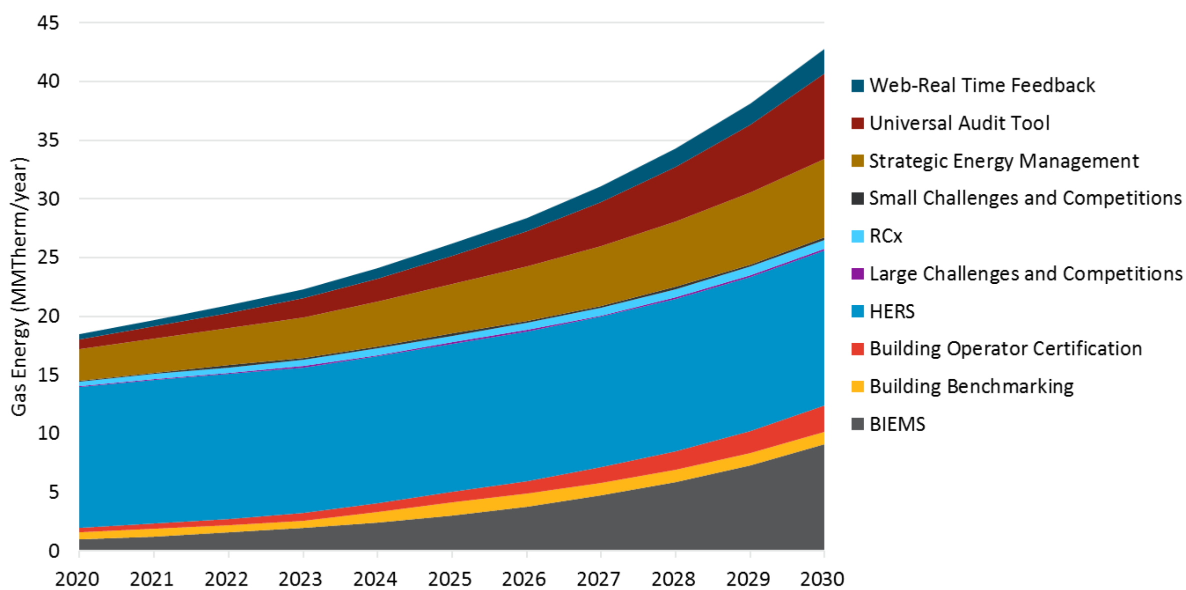
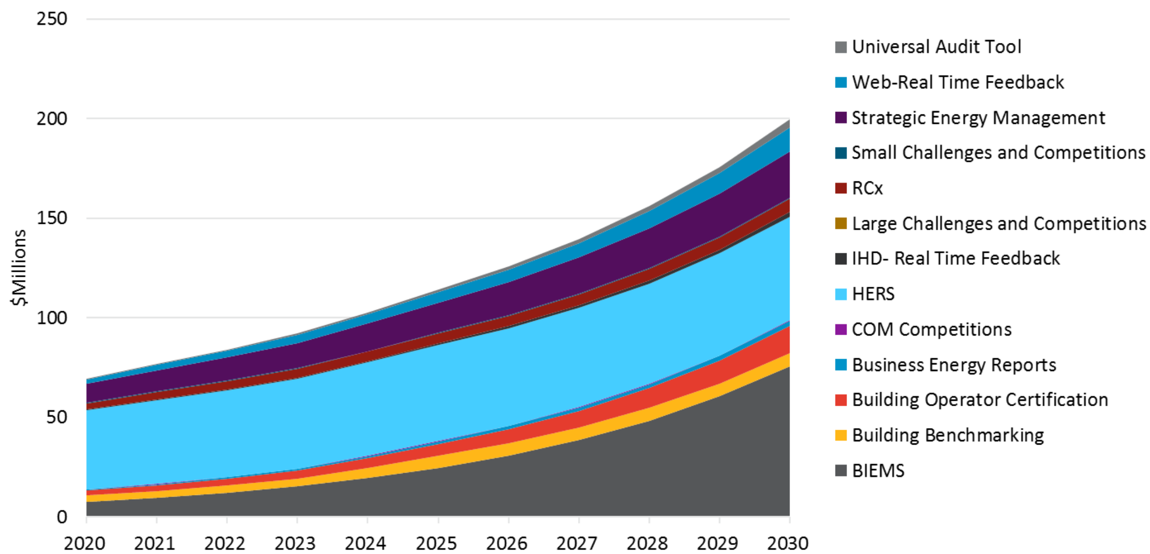



**Figure 4-69. BROs Gas Savings – Aggressive Scenario**




[64] Stakeholders informally commented that building benchmarking may not be claimable by IOU programs given benchmarking is required by AB802. However, no data/policy was cited as definitively disallowing IOUs from claiming savings from benchmarking programs. Furthermore, there may be potential for building benchmarking savings from segments of the commercial building stock not included in the AB802 mandate. Therefore, the Navigant team continues to include it in the potential forecast for this report within the Aggressive BROs scenario

**Figure 4-70. BROs Program Spending – Aggressive Scenario**




## 4.2 C&S Savings

Incremental annual savings from C&S are illustrated in Figure 4-71 and Figure 4-72. Savings from C&S are similar to those estimated in the 2017 Study. Key changes of note are listed below:

- IOU claims for 2019 Title 24 are lower than those savings estimated in the 2017 Study.
- This study includes estimates for 2022 Title 24; these were not previously included in the mid-case of the 2017 Study.
- This study includes additional/updated standards claimed by the IOUs not included in the 2017 Study. Through informal comments, consultants to the IOU's noted that IOU C&S claims for lighting include LED savings (i.e. saving that exceed a CFL baseline).

The team performed a high level review of the estimates the IOUs provided in their claims. Furthermore, the team notes that some C&S not on the books are inherently uncertain. C&S savings estimates represent the best estimate based on available data.

Incremental savings seems to decrease in the outer years as the market impacted by a code or standard has completely turned over and savings from the retrofit market are no longer counted.

**Figure 4-71. C&S Electric Savings (Including Interactive Effects)**

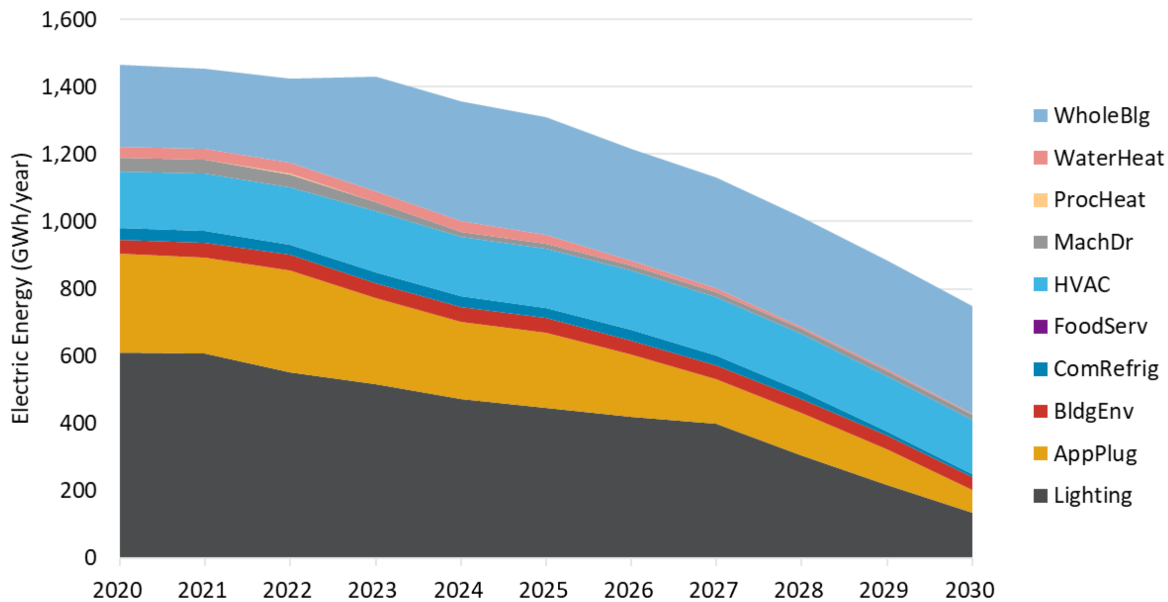
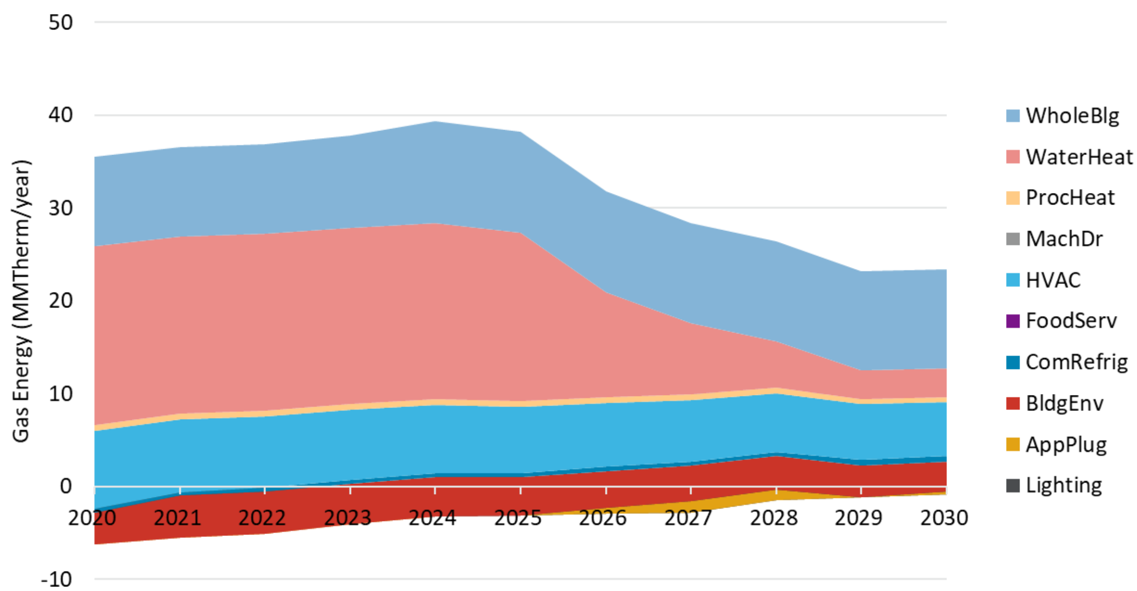



**Figure 4-72. C&S Gas Savings (Including Interactive Effects)**




Additional versions of Figure 4-71 and Figure 4-72 for each IOU and including peak demand savings can be found in the results viewer, under the Codes & Standards tab.

## 4.3 Detailed Study Results

Along with the model file and the summary results shown above, the Navigant team developed a web-based tool, the 2019 PG Results Explorer. The Results Explorer provides stakeholders the ability to manipulate and visualize model outputs. A separate database of measure-level results for rebate programs is also made available with this release.

The Results Explorer is a web-based tool that lets users explore the results of the five modeled scenarios in this study. Users can look at energy savings in terms of the total savings, incremental savings due to each program, cumulative savings over time, and the spending from the utility rebate programs; users can also see savings by the following:

- **Savings type:** Electrical energy, peak power demand, and natural gas
- **Service territory:** PG&E, SDG&E, SCE, and SCG
- **Scenario:** Five scenarios based on varying cost ratio thresholds and aggressiveness of program marketing by program administrators
- **Sector:** Covers residential, low income housing, commercial, industry, agriculture, mining, and street lighting
- **End-use category:** Includes appliances and plug loads, lighting, HVAC, data centers, process heat and refrigeration, oil and gas extraction, and food service

The full results viewer can be found at [https://bit.ly/2019-CA-Energy-Efficiency-PG-Study.](https://bit.ly/2019-CA-Energy-Efficiency-PG-Study)

### *4.3.1 Results Explorer Tabs*

The Results Explorer consists of 12 tabs. The Welcome and Data Key tabs give a short overview of the project, viewing dimensionality, and key definitions used throughout the results tabs. The User Guide tab contains a detailed user's guide for the Results Explorer, including animated GIFs showing the process for changing graph dimensionality, drilling down into data, and exporting selected graphs to Excel and CSV formats. The remaining tabs allow users to view and slice data in a variety of ways, from high level statewide to granular utility and end-use-specific results. Results tabs include the following:

- **Market Potential:** Market potential is the EE savings that could be expected in response to specific levels of incentives and assumptions about market influences and barriers. Market potential is used to inform the utilities' EE goals, as determined by the CPUC. Data presented here includes all sources of savings examined in this study. Note that C&S savings includes interactive effects.
- **Program Spending:** Utility program spending includes incentives and non-incentive costs paid for equipment rebate programs (inclusive of low income) and BROs interventions. This data does not include costs associated with non-resource programs or C&S advocacy.
- **Savings Scenarios:** Detailed data on market potential across each of the five modeled scenarios. Dimensions include end use, building type, sector, and service territory. Market potential includes rebate programs, low income, and BROs. This tab does not include C&S savings.
- **Spending Scenarios:** Detailed data on program spending across each of the five modeled scenarios. Dimensions include sector, scenario, and service territory. Utility program spending includes incentives and non-incentive costs paid for equipment rebate programs and BROs interventions. This data does not include costs associated with non-resource programs or C&S advocacy.
- **Tech/Econ/Market Potential:** Detailed data on technical, economic, and cumulative market potential from IOU equipment rebate programs. These graphs do not show IOU claimable

savings from behavior or C&S advocacy programs because the technical and economic potential for these sources are undefined. Technical potential is based on instantaneous potential, which is defined as the amount of energy savings that would be possible if the highest level of efficiency for all technically applicable opportunities to improve EE were taken. It does not account for equipment stock turnover. Economic potential is the subset of technical potential that is cost-effective under the relevant screening test in each scenario.

- **Rebate Prog. Savings by End Use:** Detailed data on market potential from rebate programs (inclusive of low income programs) by end use, sector, building type, and service territory.
- **Cost-Effectiveness:** C-E ratio compares total program benefits to total program costs for the portfolio of forecast measures under the equipment rebate programs for each IOU and each scenario. Tests define costs and benefits differently, and all are defined by the California Standard Practice Manual. The three cost tests shown are the TRC, PAC, and RIM tests.
- **Behavior Programs:** Detailed data only for behavior, retrocommissioning, and operational efficiency (BROs) programs. Dimensions include building type, sector, and service territory. Results are viewed at the BROs measure level.
- **Codes and Standards:** Detailed results only for C&S. Dimensions include end use, sector, and service territory. Results are shown in two forms: with and without interactive effects.

Each results tab includes a description of the viewable data, dynamic chart, drop down filters for available chart configuration dimensions, and instructions for frequently performed tasks. The viewer is illustrated in Figure 4-73 and Figure 4-74.

**Figure 4-73. Results Explorer Tab Configuration (Illustrative)**

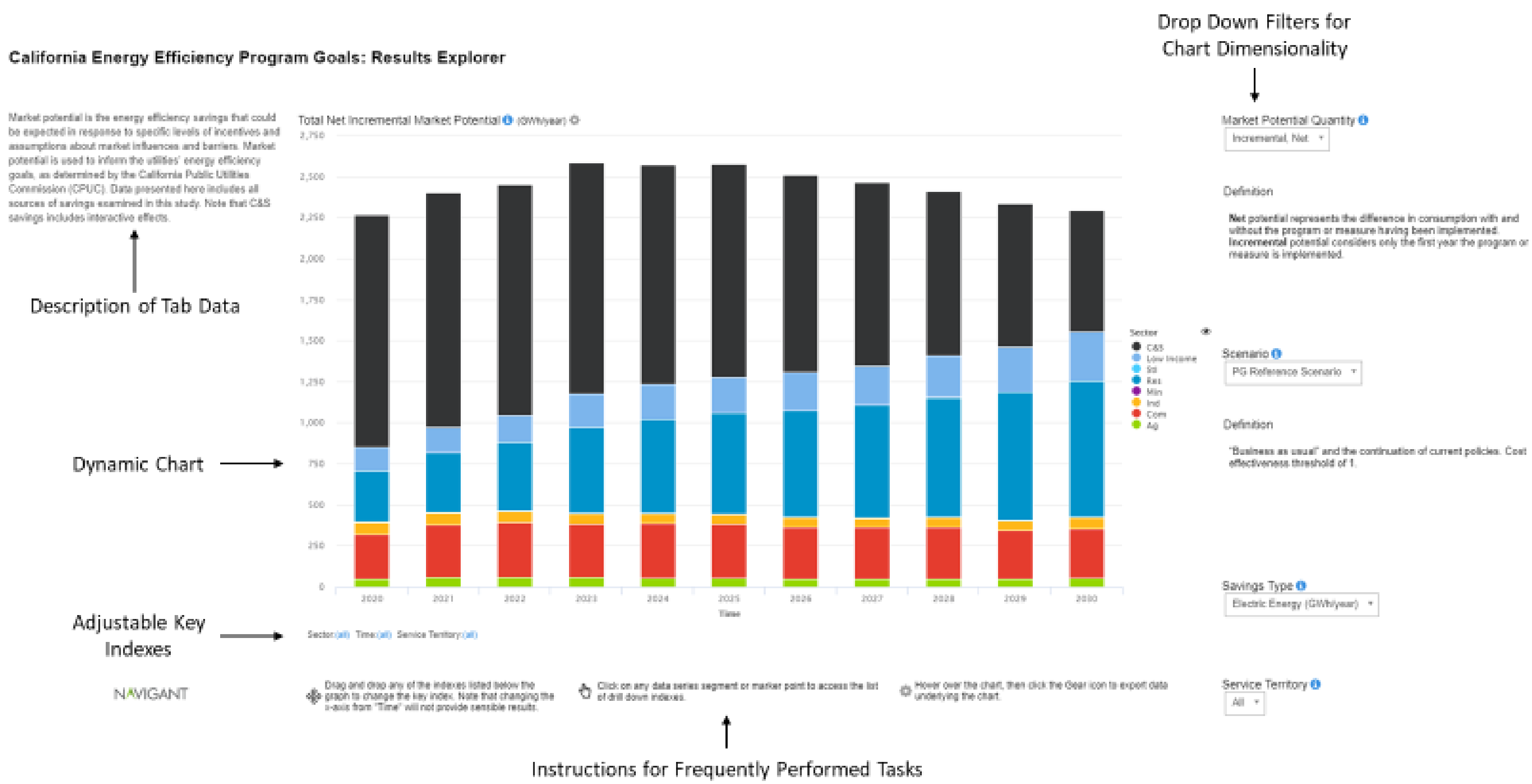
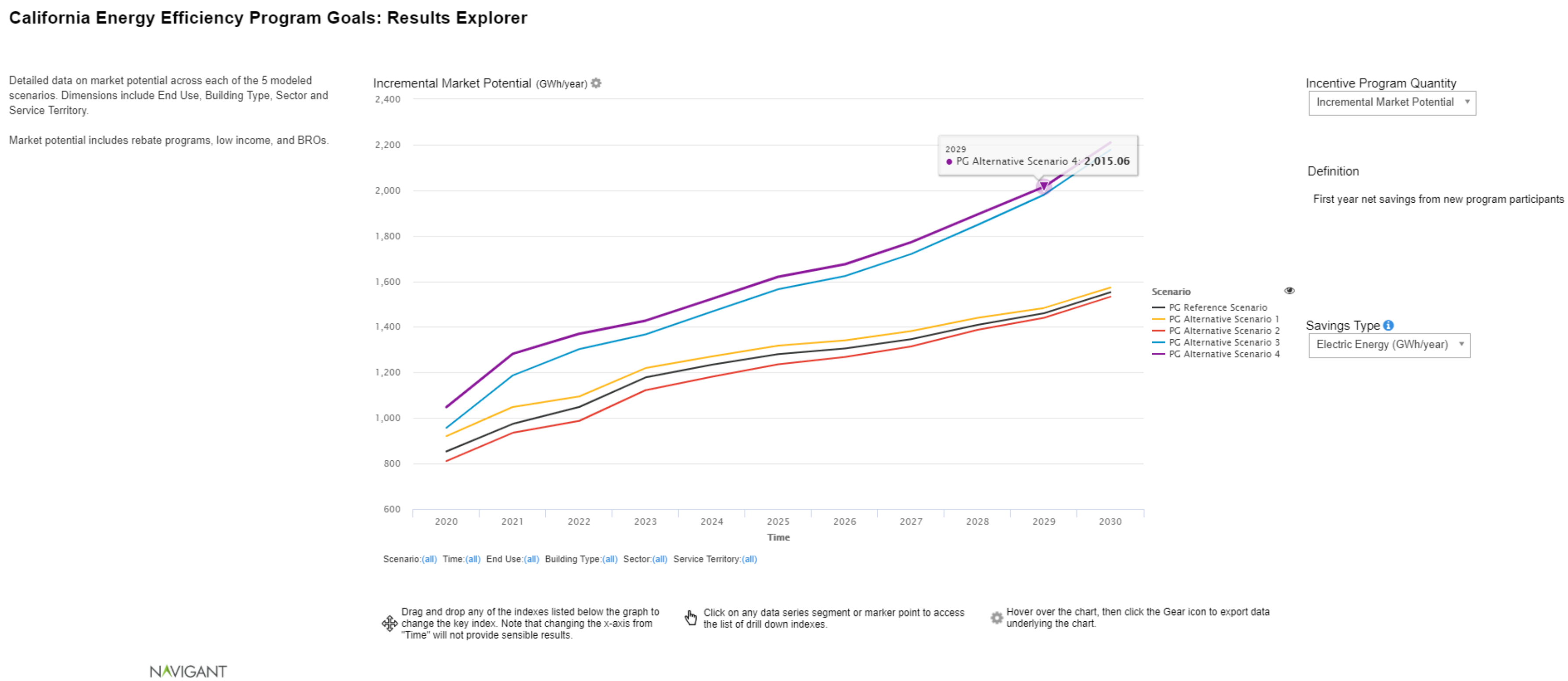


**Figure 4-74. Results Explorer Scenario Comparison (Illustrative)**



# 5. LOW INCOME PROGRAMS

The potential for EE in the low income sector is modeled after the Energy Savings Assistance (ESA) program. The ESA program is offered by all four IOUs as a no-cost, direct installation of measures. The program includes a wide range of equipment combined with education and referrals to other income-qualified programs.

The 2019 Study makes a major update to the forecast methodology for the low income sector. In the 2017 Study, the Navigant team forecast savings using a simple top-down methodology. The method multiplied expected number of future participants by overall participant unit energy savings (UES). Data for future participation and UES was obtained from the IOUs via a data request. At the time, IOUs expected all program participants starting in 2021 would be retreatments (i.e., homes that have participated in the program in years past receiving additional treatment). The expected UES for retreatments at the time was lower than first-time treatments.

In this study, the low income sector is modeled using the same methodology as rebate programs (described earlier in Section 2.1.1). This is a shift from the previous top- down approach to a measure-based bottom- up forecast. Low income is separated into its own sector apart from the residential sector in the model. Rebates applied to the low income sector are equal to 100% of equipment cost.

Historically, ESA programs were not required to pass a total resource cost (TRC) test, and they do not feed into the overall portfolio cost-effectiveness for IOU programs. Informal stakeholder comments further suggested that economic potential not be calculated for low income programs as it is largely an academic endeavor. As such, the model does not conduct any measure C-E screening for low income measures.

## 5.1 Low Income Program Data Sources

Data for low income programs was primarily obtained from secondary data. Key sets of data include building stock and retail rates (categorized as global inputs) and measure-level data.

### *5.1.1 Building Stock and Retail Rates*

Using data analyzed from a combination of the Low Income Needs Assessment,[65] eligibility statistics for the California Alternate Rates for Energy (CARE)[66] program, and county-level statistics on the multifamily market from the American Community Survey,[67] the Navigant team estimated the fraction of the population in each IOU territory that would qualify for low income programs. This data is summarized in Table 5-1. and is applied to the residential building stock forecast (described earlier in Section 3.1.2) to split the total residential stock into low income versus non-low income. The fraction of single-family and fraction of multifamily are independent market estimates and, therefore, do not sum to 100%. Data for

[65] Evergreen Economics. *Needs Assessment for the Energy Savings Assistance and the California Alternate Rates for Energy Programs*. 2016.

[66] California Public Utilities Commission. *Compliance Filing of Pacific Gas and Electrics (U 39-M), on behalf of itself, Southern California Gas Company (U 904-G), San Diego Gas and Electric Company (U 902-M), and Southern California Edison Company (U 338-E), Regarding Annual Estimates of CARE Eligible Customers and Related Information*. February 9, 2018.

[67] https://www.census.gov/programs-surveys/acs/, accessed January 2019.

PG&E was revised to reflect information provided in PG&Es formal comments on the previous draft of this report.[68]

**Table 5-1. Fraction of Households Considered Low Income**

| Utility | Fraction of Single-Family Homes that are Low Income | Fraction of Multifamily Homes that are Low Income |
|---|---|---|
| PG&E | 20.2% | 37.9% |
| SCE | 29.4% | 38.0% |
| SDG&E | 19.7% | 42.0% |
| SCG | 28.6% | 41.9% |

The 2020 model assumes low income customers are enrolled in CARE and thus receive a discount on their energy rates. Discount factors are presented in Table 5-2.

**Table 5-2. Low Income Energy Rate Discounts**

| Fuel | Percent Discount | Data Source(s) |
|---|---|---|
| Electric | 35% | • http://www.cpuc.ca.gov/general.aspx?id=976<br>• SDG&E: Rate class E-CARE states that in 2020 and beyond effective discount will be 35%<br>• Comparison of 2019 PG&E Rate class E-1 vs. EL-1 (CARE) |
| Natural Gas | 20% | • http://www.cpuc.ca.gov/general.aspx?id=976<br>• SoCalGas 2019 GR-CARE Rate Class |

### *5.1.2 Measure-Level Data*

The measure list and measure-level data for the low income sector is adapted from the residential (non-low income) sector. Four key differences are accounted for:

- **Measure applicability:** Only a subset of residential measures applies to the low income sector. The Navigant team removed measures not likely to be rebated or not historically rebated by ESA. Examples include ZNE whole building new construction, drain water heat recovery, ENERGY STAR TVs, cool roofs, and clothes dryers. A full list of which measures were included in the modeling of the low income sector can be found in the 2019 MICS database (described earlier in Section 1.6).
- **NTG ratio:** ESA does not apply a NTG value; rather, it assumes a NTG of 1.0. Therefore, measures in the low income sector use a NTG of 1.0 rather than the deemed or evaluated NTG that applies to residential programs.

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[68] PG&E. *Comments of Pacific Gas and Electric Company (U 39 M) Regarding Energy Efficiency Potential And Goals For 2018 And Beyond In Response To Administrative Law Judge's Ruling Dated May 1, 2019*. May 21, 2019

- **Unit energy savings:** The ESA program has historically estimated savings leveraging ex ante data from DEER. However, a recent impact evaluation of the 2015-17 ESA programs revealed significant variations in evaluated savings relative to ex ante estimates.[69] This study applies measure level realization rates from the ESA impact evaluation to more accurately represent the unit energy savings expected from measures adopted by ESA.[70] The PG Model is not capable of forecasting increases in energy use. Therefor if measures are expected to increase energy use, their impacts are omitted from the forecast.

- **Measure prevalence and efficiency:** Measure prevalence refers to the ownership levels of equipment in the low income sector relative to the broader residential population. Measure efficiency refers the saturation of efficient technologies in the low income sector relative to the broader residential population. Both items are described in greater detail in the rest of this section.

The Navigant team reviewed existing sources of low income residential market data and compiled key statistics about measure prevalence and efficiency. The Navigant team sought out the following two ratios for each of the measures as shown in Table 5-3..

**Table 5-3. Low Income Ratio Descriptions**

| Ratio Type | Ratio Calculation | Example Description |
|---|---|---|
| **Total Density Ratio** | Total density among low income sample / total density among general population sample | A ratio of 75% means that low income customers are 25% less likely to own a thermostat than the general population.[71] |
| **Baseline Saturation Ratio** | Average existing equipment prevalence among low income sample / average existing equipment prevalence among general population sample | A ratio of 131% means low income households with thermostats are 31% more likely to own a manual thermostat (average existing case) than the general population. |

The Navigant team obtained information for the two ratios by reviewing the following data sources:

- Data in the 2012 CLASS webtool[72]
- 2013 Low Income Needs Assessment (LINA)[73]
- ESA Program Multifamily Segment Study [74]

The Navigant team used data from the CLASS webtool as the primary source to develop the density and saturation ratios. The team referenced the 2013 LINA and ESA study for context, particularly to understand the population of low income households across California.

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[69] DNVGL. *Energy Savings Assistance (ESA) Program Impact Evaluation Program years 2015–2017*. April 2019

[70] Realization rates obtained from Figure 5-8 and Figure 5-17 from the ESA impact evaluation report. These are applied to unit energy consumption and savings values for residential measure to arrive at values that can be used for the low income program.

[71] In the case of a thermostat, lack of ownership implies the homeowner does not control the temperature setpoint in the building

[72] https://webtools.dnvgl.com/projects62/Default.aspx?tabid=190

[73] Evergreen Economics. *Needs Assessment for the Energy Savings Assistance and the California Alternate Rates for Energy Programs, Final Report (Study ID: SCE0342), Volume 2: Detailed Findings*. 2013 See p. 4-21.

[74] Cadmus and Research Into Action (2013). ESA Program Multifamily Segment Study Report.

The CLASS webtool provides statistical summaries of lighting and appliance prevalence. Data are presented in terms of percentages (e.g., percentage of homes with at least one piece of equipment, percentage of equipment units that are within binned ranges of efficiency values) and averages (e.g., average SEER of cooling equipment).

The 2013 LINA study showed the average low income household has approximately three people, and the CARE guidelines limit income for a three-person household to $41,560. Therefore, the Navigant team searched for households of three or less people with a maximum income of $40,000 in the CLASS webtool to represent the low income population.

Table 5-4. summarizes the criteria that the Navigant team used to select and extract data from CLASS and divide that data into the low income population versus the general population.

**Table 5-4. CLASS Filter Criteria Used to Extract Data**

| Data Subset | CLASS Filter Criteria |
|---|---|
| **Income Group** | |
| General Population | Total People in Home: Any |
| | Income: Any |
| Low Income | Total People in Home: 1, 2, 3 |
| | Income: <$20,000, $20,000 to <$30,000, $30,000 to $40,000 |
| **Home Type** | |
| Single-Family | Type of Residence: Single-Family Detached, Apt 2-4 Units, Duplex (Single Story), Mobile Home, Townhouse/ Rowhouse (2-4 Unit Multi-Story) |
| Multifamily[75] | Type of Residence: Apt 5+ Units |

The Navigant team multiplied the general population density and baseline saturation values by the low income ratios to calculate the low income total density and saturations. An example of this calculation can be found in Table 5-5.. Note that Code and Efficient Base Year Efficiency saturations maintain the same relative proportions to each other as they do in the general population saturations.

**Table 5-5. Low Income Total Density and Saturation Example**

| Technology Name | Base Year Efficiency | Total Density | Low Income Total Density Ratio | Low Income Total Density | Technology Saturation | Low Income Baseline Saturation Ratio | Low Income Saturation |
|---|---|---|---|---|---|---|---|
| Manual Thermostats | Average Existing | 0.97 | 75% | 0.73 | 46% | 131% | 61% |
| Programmable Thermostats | Code | 0.97 | 75% | 0.73 | 51% | - | 37% |
| Smart Thermostats | Efficient | 0.97 | 75% | 0.73 | 3% | - | 2% |

[75] Note that some IOUs use a slightly different criteria for their multifamily upgrade programs.

The Navigant team focused on collecting data for measures in order of priority. Highest priority measures were initially determined as those that have collectively contributed to the top 80% of historic ESA program savings though additional measures that were added contribute large potential savings to non-low income programs.[76] Medium and low priority measures were those that were historically part of ESA but at lower savings/participation levels. Some measures did not have discernable low income versus general population data; for these measures, the team made proxy estimates of the above described ratios. Prioritization does not imply what programs do or should prioritize, but rather the Navigant team's data collection prioritization process. Prioritization is listed in Table 5-6..

**Table 5-6. Low Income Measure – Data Collection Prioritization**

| High Priority | Medium Priority | Low Priority |
|---|---|---|
| Air Conditioners | Clothes Dryers | Attic Duct Insulation |
| Ceiling/Roof Insulation | Clothes Washers | Crawlspace Duct Insulation |
| Faucet Aerators | Lighting Fixtures | Elec Water Heaters |
| Furnaces | Reflector Lamps | Freezers |
| Gas Water Heaters | Windows | Linear Fixtures |
| HVAC Quality Maintenance | Room AC | Lamps – Outdoor |
| Refrigerators | Specialty Lamps | |
| Screw-In Lamps – Indoor | Water Heating Controls | |
| Showerheads | | |
| Wall Insulation | | |

## 5.2 Low Income Program Results

Figure 5-1 through Figure 5-4 show the breakdown of electric savings by end use in the commercial sector for each scenario. Detailed tables of results for each IOU can be found in Appendix H. The Reference, Alternative 1, and Alternative 2 scenarios have the same savings results, so they are grouped into one figure. The same applies for the Alternative 3 and Alternative 4 scenarios. Key observations from these figures include the following:

- The appliances and HVAC end uses account for most of the electric potential, with lighting playing a smaller role in electric potential. Meanwhile, the water heating end use dominates gas savings opportunities.
- These figures show the incremental first-year savings from new participants. It does not include savings from re-participants to remain consistent and comparable to other figures in this report. Savings from re-participants are captured in the cumulative savings calculation in the PG Model.
- These figures apply realization rates from recent the ESA EM&V study.[77] As a results savings are significantly lower then those presented in the earlier draft of this report.

As noted earlier, this study significantly updated the forecasting approach for the low income sector. The 2017 Study's top-down approach relied significantly on data reported by the IOUs and the expectation that, starting in 2021, program participants would consist only of retreatments (i.e., homes that have

[76] Historic ESA program savings obtained from annual reports for 2017 available at: http://www.cpuc.ca.gov/iqap/

[77] DNVGL. *Energy Savings Assistance (ESA) Program Impact Evaluation Program years 2015–2017*. April 2019

participated in the program in previous years). The 2019 Study seeks to assess the true remaining potential in low income homes at the measure level regardless of if the residential customer is a first-time participant or a re-participant. As such, forecast potential in 2020 and beyond is agnostic of past program participation.

**Figure 5-1. Statewide Low Income Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Reference, Alternative 1, and Alternative 2)**

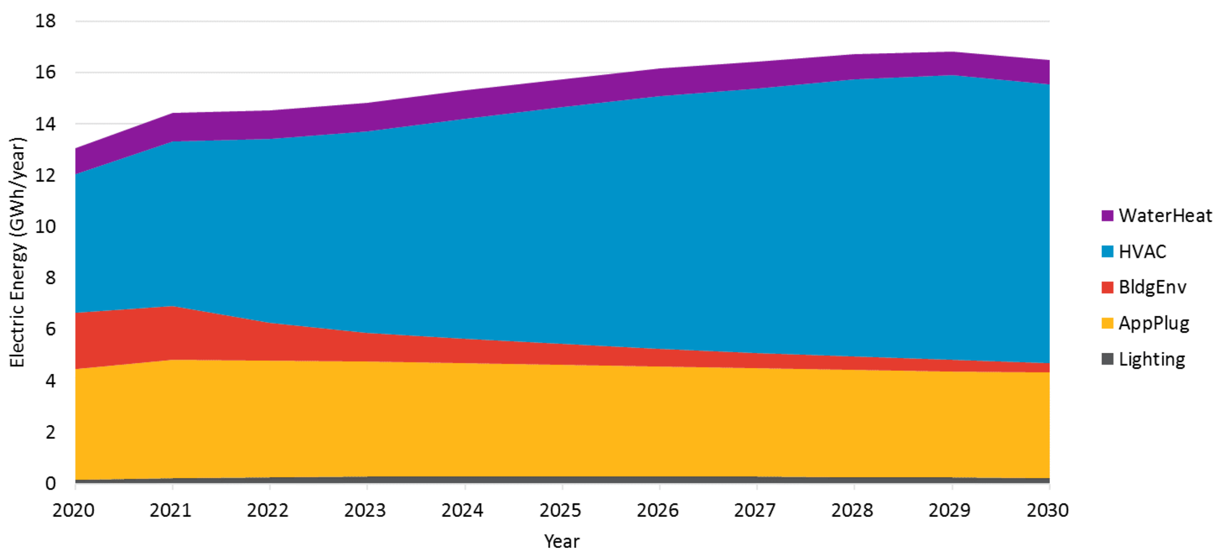



**Figure 5-2. Statewide Low Income Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 3, Alternative 4)**

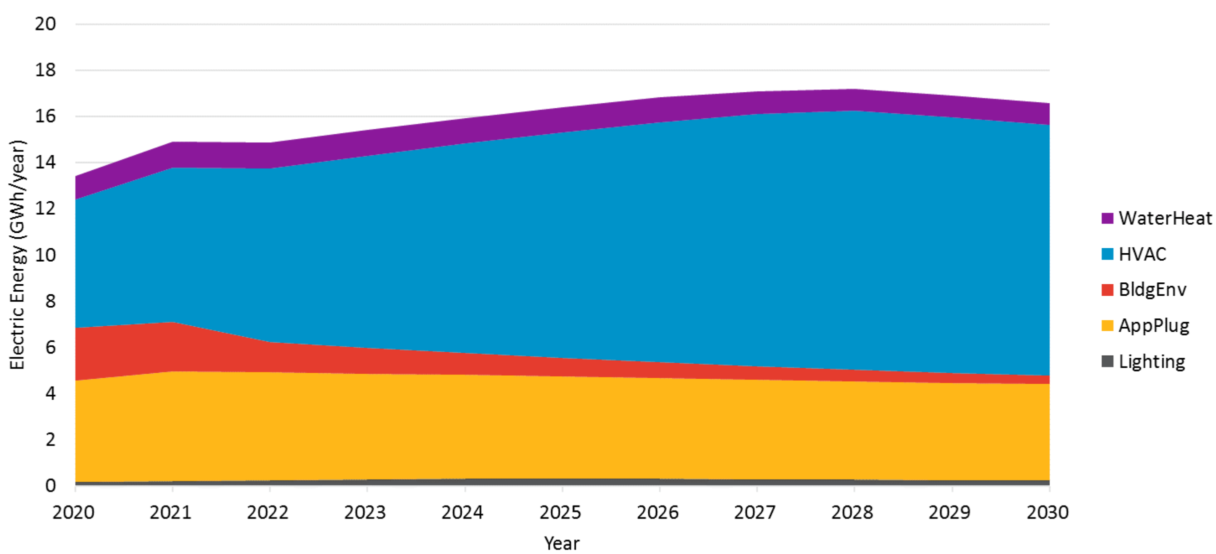


**Figure 5-3. Statewide Low Income Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Reference, Alternative 1, and Alternative 2)**

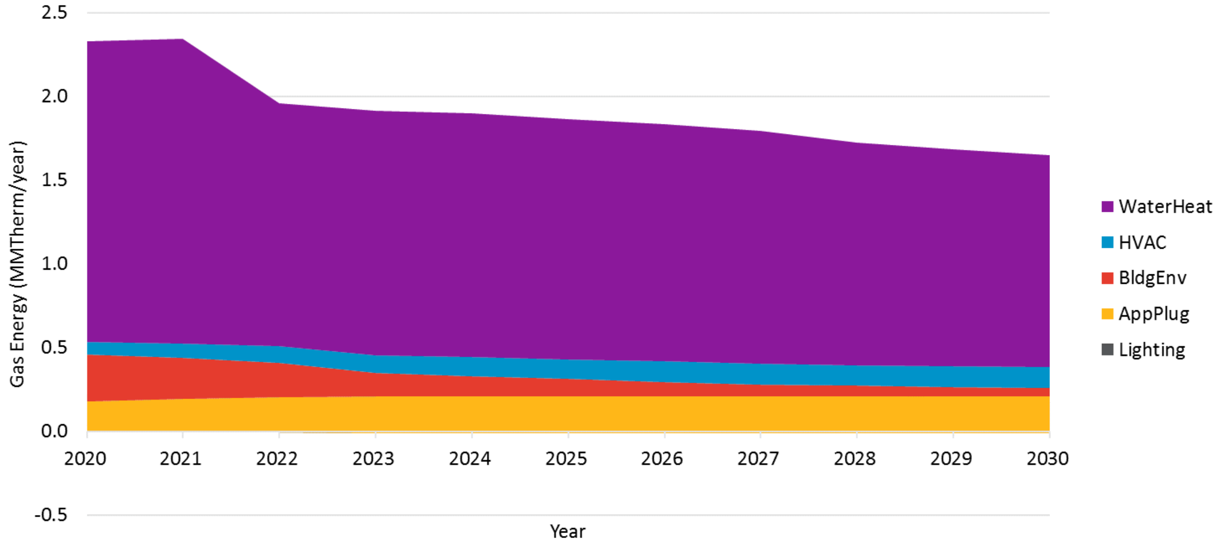
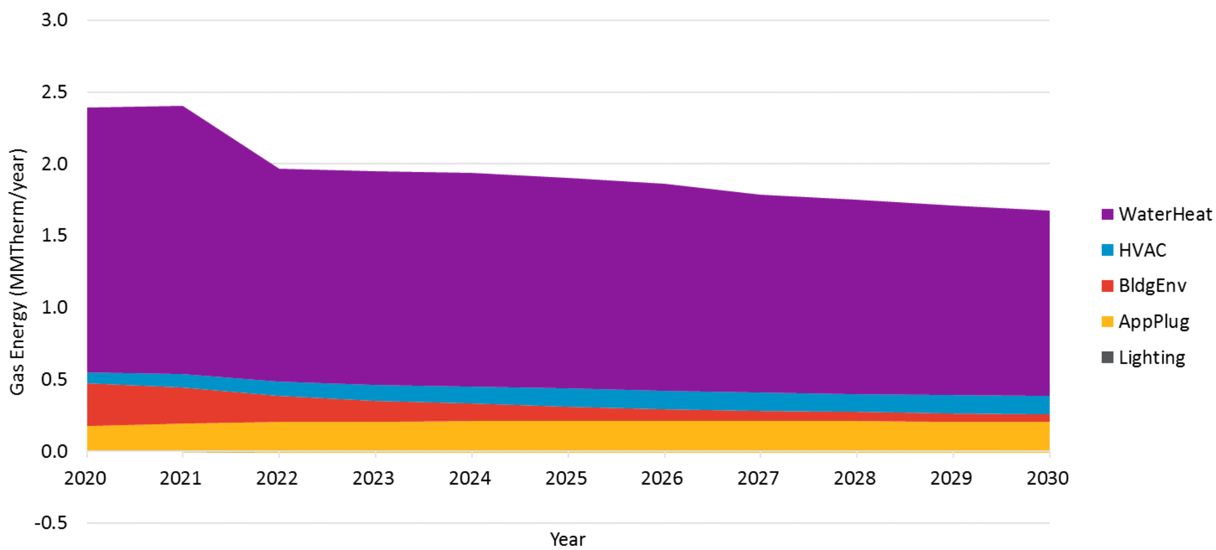



**Figure 5-4. Statewide Low Income Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 3, Alternative 4)**



# APPENDIX A. CALIBRATION

## A.1 Overview

Forecasting is the inherently uncertain process of estimating future outcomes by applying a model to historic and current observations. As with all forecasts, the PG Model results cannot be empirically validated a priori, as there is no future basis against which one can compare simulated versus actual results. Despite that all future estimates are untestable at the time they are made, forecasts can still warrant confidence when historic observations can be shown to reliably correspond with generally accepted theory and models.

Calibration provides both the forecaster and stakeholders with a degree of confidence that simulated results are reasonable and reliable. Calibration is intended to achieve three main purposes:

- Anchors the model in actual market conditions and ensures that the bottom-up approach to calculating potential can replicate previous market conditions.
- Ensures a realistic starting point from which future projections are made.
- Accounts for varying levels of market barriers and influences across different types of technologies. The model applies general market and consumer parameters to forecast technology adoption. There are often reasons why markets for certain end uses or technologies behave differently than the norm—both higher and lower. Calibration offers a mechanism for using historic observations to account for these differences.

The calibration process is not a regression of savings or spending (not drawing a future trend line of savings based on past program accomplishments). Rather, calibration develops parameters that describe the customer decision-making process and the velocity of the market based on recent history. Once these parameters are set, the model uses them as a starting point for the forecast period

The PG Model was calibrated in two steps. First, a draft calibration was conducted based on historic data from 2013 through 2016. Second, the draft calibrated results were reviewed with stakeholders to incorporate effects post-2017 and the collective insights of stakeholders on how the future may differ from the past.

Step 1 calibrated by reviewing portfolio data from 2013 through 2016[78] to assess how the market has reacted to program offerings in the past. The calibration starts in 2013 because a key input to the model (equipment saturation data) was based on data collected in the 2012-2013 timeframe. Thus, the model must begin in the same year that its equipment stock data begins.

[78] Calibration extends through 2016 rather than 2017 or 2018 due to the timeline constraints placed on this study. The 2017 model and study was set up to extract and process calibration data from the CPUC's EEStats website. EEStats provides data up through 2016. Program data (including program plans) for 2017 and beyond are housed on the CPUC's CEDARS website. Mining data from CEDARS under the short timeline of this project was not possible.

Step 2 allows for calibration to account for more recent changes to programs. The Navigant team held a workshop on March 21, 2019 to present preliminary draft results of the residential, commercial and industrial sectors to stakeholders. Following the presentation was a discussion of the following:

- Stakeholder impressions/reactions to the magnitude of the savings and breakdown across different end uses
- Stakeholder input on future trends not captures during the historical calibration
- Stakeholder insights regarding specific sectors/end uses will be significantly impacted by program changes (positive or negative)
- Defensible reasoning to support any suggested changes

## A.2 Necessity of Calibration

Senate Bill 350 direct the following: *"In assessing the feasibility and cost-effectiveness of energy efficiency savings … the Public Utilities Commission shall consider the results of energy efficiency potential studies that are not restricted by previous levels of utility energy efficiency savings."* This does not imply that a potential study should not be calibrated.

Calibration refers to the standard process of adjusting model parameters such that model results align with observed data. In evaluative statistical models, calibration is called regression, and goodness of fit is typically the main focus since the models are usually simple. In situations of complex dynamics and non-linearity (as in this study), model sophistication and adequacy can become the main focus. But grounding the model in observation remains equally necessary. The ability of a forecast to reasonably simulate observed data affords credibility and confidence to forecast estimates.

Although there are data supporting all underlying parameters in the PG Model, much of the data are at an aggregate level that can be inadequate to forecast differences across the various classes of technologies and end uses. The customer willingness-to-adopt factor is a good example of this effect. Customers may exhibit certain average purchase tendencies in adopting measures based on their financial characteristics. Nevertheless, there may be features of certain end use technologies that cause customer behavior to vary from the average. Residential building envelope is an end use where adoption of measures like insulation is consistently lower than would be predicted compared with other end uses. Residential lighting adoption, on the other hand, performs better than the average predicted customer purchase tendencies, even after adjusting for differences in financial attractiveness. We often think of these differences as the influence of non-financial product attributes or of market barriers.

Calibration is not an optional exercise in modeling. One might suggest that the average customer data should be sufficient to make a reliable aggregated forecast. Nevertheless, there are two important non-linearities that compel us toward a more granular parameterization:

- Program portfolios are not evenly composed across end-uses. This leads to an uneven weighting issue whereby average customer willingness and awareness may not lead to the correct calculation of total savings and costs.
- The dynamics in the model regarding the timing of adoption can become incompatible with the remaining potential indicated by program achievements. For example, if the forecast results were not calibrated for LED lighting in the residential sector, the saturation may remain inaccurately low in early years and indicate a larger remaining potential in future years. Thus calibrating upward

may increase potential in the early years but decrease potential in later years. This implies that in the absence of IOU program intervention, residential LED would have historically had much lower adoption. Calibration therefore allows us to capture these program influences to more accurately reflect remaining potential.

The team treats the calibrated results as the most basic set of interpretable results from which alternate scenarios are developed.

## A.3 Interpreting Calibration

Calibration can constrain market potential for certain end uses when aligning model results with past IOU energy efficiency (EE) portfolio accomplishments. Although calibration provides a reasonable historic basis for estimating future market potential, past program achievements may not capture the potential due to structural changes in future programs or changes in consumer values. Calibration can be viewed as holding constant certain factors that might otherwise change future program potential, such as:

- Consumer values and attitudes toward energy efficient measures;
- Market barriers associated with different end uses;
- Program efficacy in delivering measures; and
- Program spending constraints and priorities.

Changing values and shifting program characteristics would likely cause deviations from market potential estimates calibrated to past program achievements.

Does calibrating to historic data constrain the future forecast? In a strictly numeric sense, yes. If a certain end use is calibrated downward or upward, then future adoption and its timing are affected. Nevertheless, this should not be interpreted as “calibration constrains the level of adoption that we think is possible.” Rather calibration provides a more accurate estimate of the rate of technology turnover in the market, current state of customer willingness, market barriers, program characteristics and remaining adoption potential

One interpretation is that the calibration process creates a floor for the remaining potential. Market barriers, customer attitudes, and program efficacy generally move in the direction of improvement.

## A.4 Implementing Calibration

The PG study calibration process primarily seeks to develop a set of consumer decision and market parameters that best represent recent history. Once these parameters are developed they are used as the start point of the PG Model’s stock turnover algorithms and consumer decision algorithms.

The process of developing these parameters requires historic market data. The PG Model uses 2013-2016 program data (net savings, gross savings, program spending data)[79] and performs a “back cast” to

[79] See http://eestats.cpuc.ca.gov

fit model parameters such that historic achievements are generally matched. Frequently asked questions about this process and their answers include:

- **Why start in 2013?** This the year where we have holistic saturation data for the entire market of EE technologies, it is a reasonable market starting point.
- **Why end in 2016?** Our model was set up to extract data from EEStats (this data source goes through 2016).
- **Can we calibrate using 2017-2018 data?** We would still need to use 2013-2016 data and append it with additional years.

The calibration process was conducted in two steps.

In Step 1, the Navigant team adjusted model parameters and compared the "back-cast" of the model against historic program data for 2013-2016. Individual adjustments to three key levers (listed in the table below) were made at the IOU, sector, and end use level until a reasonable match with historic data was achieved.

**Table A-1. Calibration Levers**

| Lever | Drivers and Impact on Model Results |
|---|---|
| **Awareness** | • Increasing initial awareness shortens the time required for a measure to reach 100% consumer awareness and accelerates adoption.<br>• Increasing marketing strength increases adoption rate of technologies in the nascent stage (i.e., having low initial consumer awareness). |
| **Willingness** | • Adjustments to incentive levels increase adoption, increase budget, and increase savings.<br>• Consumer implied discount rate can be adjusted to account for non-cost related market barriers that may be higher or lower than normal. |
| **Stock Turnover** | • The model assumes technologies turn over based on EUL. However, the real velocity of the market and turnover dynamics are not this perfect/exact. Adjusting turnover rates allows the model to better reflect real world market dynamics. |

Step 1 was a process relying on historic data. However, the Navigant team readily recognizes the future of consumer decisions processes and market momentum may not look like the past. For example:

- **Future Customer Decision Process:** The past decision parameters may not be representative of the future paradigm:
    - **Programs are shifting to third party:** The way programs market and influence customer decisions may change
    - **Customer have more access to their own data:** Will they be a more informed customer, or be overburdened in their own analysis paralysis?
- **Future Program Focus:** Our "Crystal Ball" is hazy when it comes to:

    - How programs will redesign to accommodate LED “standard practice baseline”
    - Recent EM&V studies/pilots provide new data that may influence the future of program offerings
    - Greater role for third party implementation
    - BROs programs that are beyond the status quo of HERs

- **Other Unknowns**

Given these uncertainties, Step 2 of the calibration process sought feedback from stakeholders on the reasonableness of the forecast resulting from Step 1 and what adjustments (if any) should be made. On March 21, 2019 the Navigant team presented preliminary draft results for the residential, commercial, and industrial sectors (which historically accounted for 85% of rebate program savings) and asked stakeholder to provide feedback and information such as:

- Impressions/reactions to the magnitude of the savings and breakdown across different end uses
- Thoughts on trends in key end uses
- Insights regarding specific sectors/end uses will be significantly impacted by program changes (positive or negative)
- Defensible reasoning to support changes

The Navigant team collected informal comments and made adjustment to the forecast period as necessary.

# APPENDIX B. TECHNICAL, ECONOMIC AND CUMULATIVE MARKET POTENTIAL FOR EQUIPMENT REBATE PROGRAMS

Figure B-1 through Figure B-10 illustrate the statewide technical, economic, and cumulative market potential from IOU equipment rebates for electric (GWh) and gas (MMtherms), respectively, for each scenario. These figures do not show IOU-claimable savings from behavior or C&S advocacy programs as the technical and economic potential for these sources are undefined. The cumulative market potential line is based on an accumulation start year of 2020 to assist in tracking additional achievable energy efficiency (AAEE) for the CEC's demand forecast and to support utility Integrated Resource Planning efforts.

The technical potential is based on instantaneous potential, which is defined as the amount of energy savings that would be possible if the highest level of efficiency for all technically applicable opportunities to improve energy efficiency (EE) were taken. It does not account for equipment stock turnover in existing buildings. For new construction buildings, technical potential reflects 100% of new construction adopting the highest level of efficiency measure in the year of construction. Furthermore, technical potential for new construction is cumulated over time starting in 2020.

The economic potential shown in the graph is a subset of technical potential that is cost-effective under the relevant screening test applied separately to existing buildings and new construction in each scenario. Both the technical and economic potential lines grow steadily over time to reflect stock growth across all scenarios.

The gap between the economic and technical potential on the graphs reflects that a significant number of measures are not cost-effective. This gap is smallest in Alternative 1 where the TRC threshold is 0.85 (compared to 1.25 in Alternative 2).

**Figure B-1. Statewide Technical, Economic, and Cumulative Electric Market Potential for Equipment Rebate Programs (Reference)**

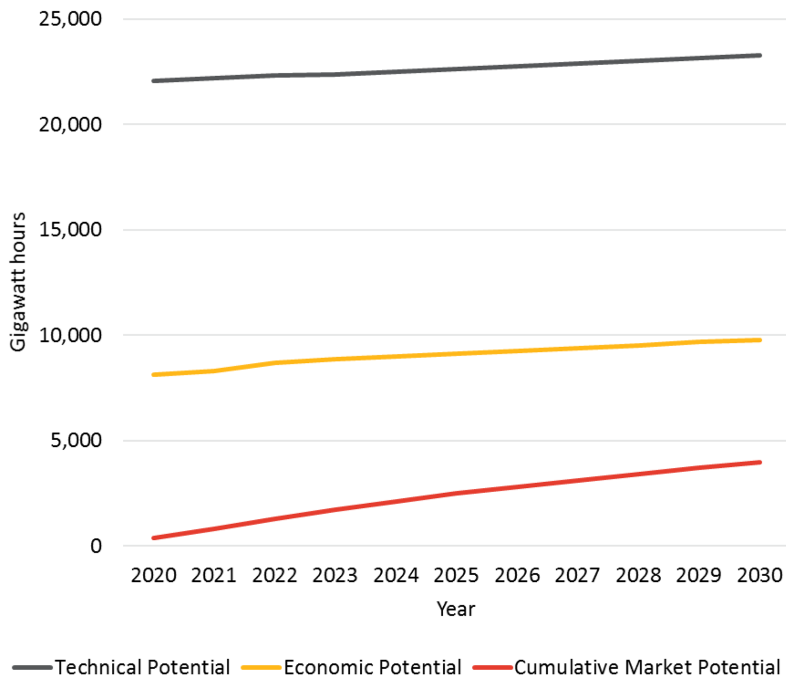



**Figure B-2. Statewide Technical, Economic, and Cumulative Electric Market Potential for Equipment Rebate Programs (Alternative 1)**

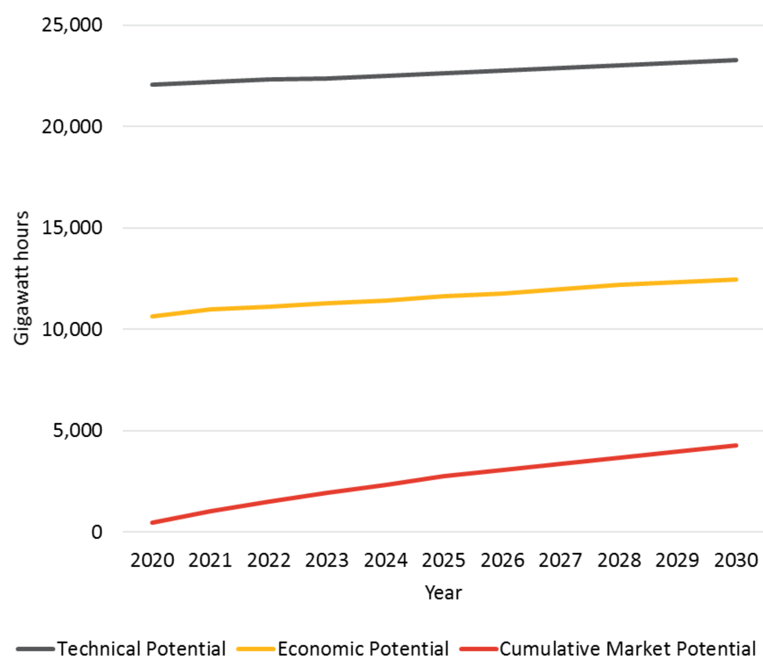


**Figure B-3. Statewide Technical, Economic, and Cumulative Electric Market Potential for Equipment Rebate Programs (Alternative 2)**

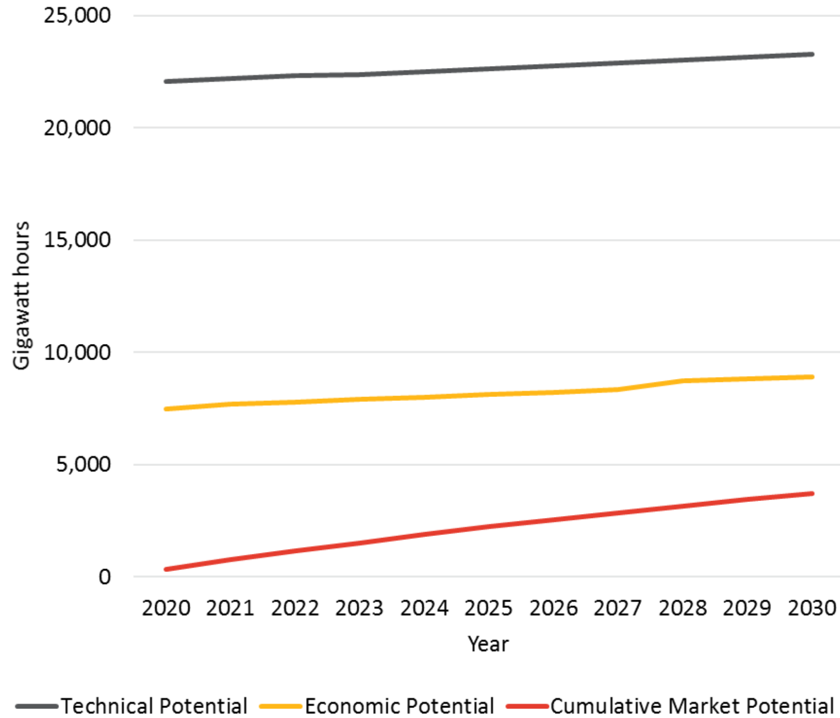



**Figure B-4. Statewide Technical, Economic, and Cumulative Electric Market Potential for Equipment Rebate Programs (Alternative 3)**

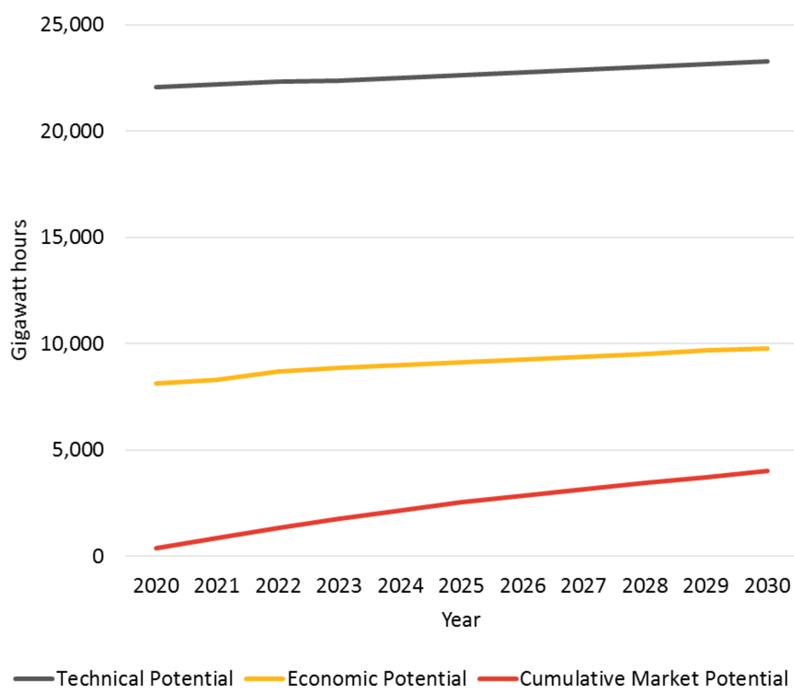


**Figure B-5. Statewide Technical, Economic, and Cumulative Electric Market Potential for Equipment Rebate Programs (Alternative 4)**

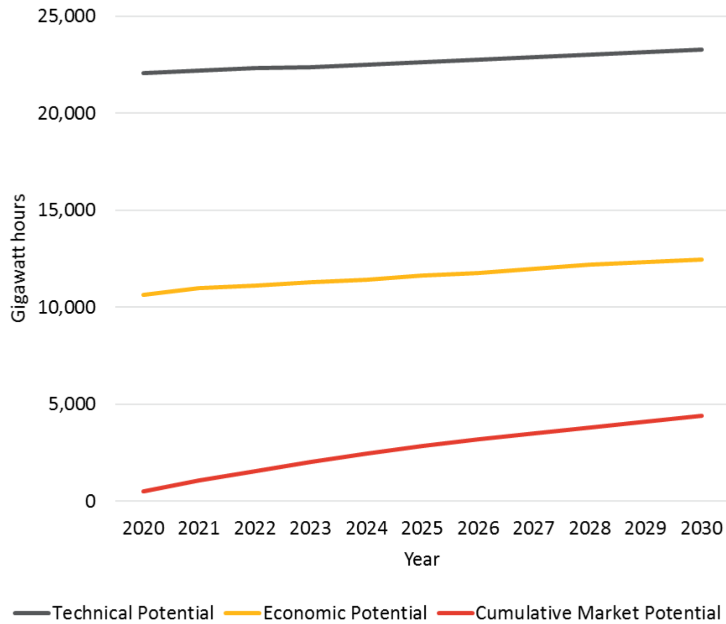



**Figure B-6. Statewide Technical, Economic, and Cumulative Gas Market Potential for Equipment Rebate Programs (Reference)**

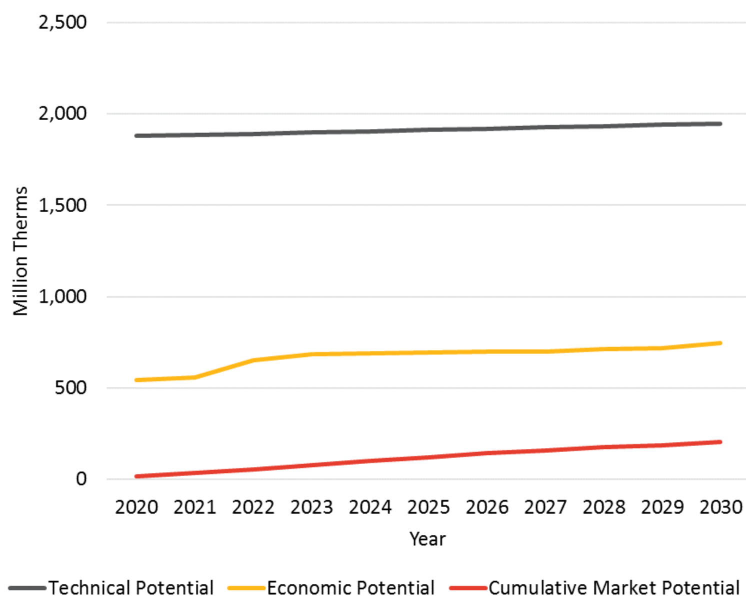


**Figure B-7. Statewide Technical, Economic, and Cumulative Gas Market Potential for Equipment Rebate Programs (Alternative 1)**

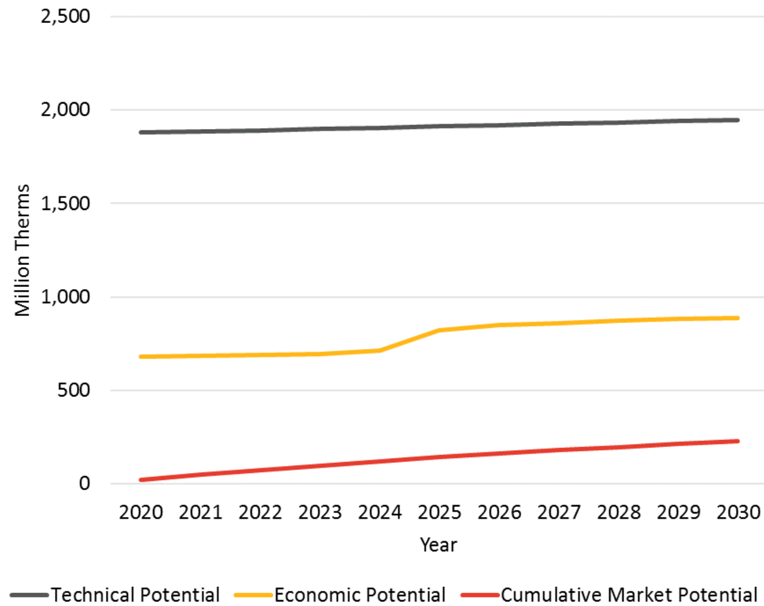



**Figure B-8. Statewide Technical, Economic, and Cumulative Gas Market Potential for Equipment Rebate Programs (Alternative 2)**

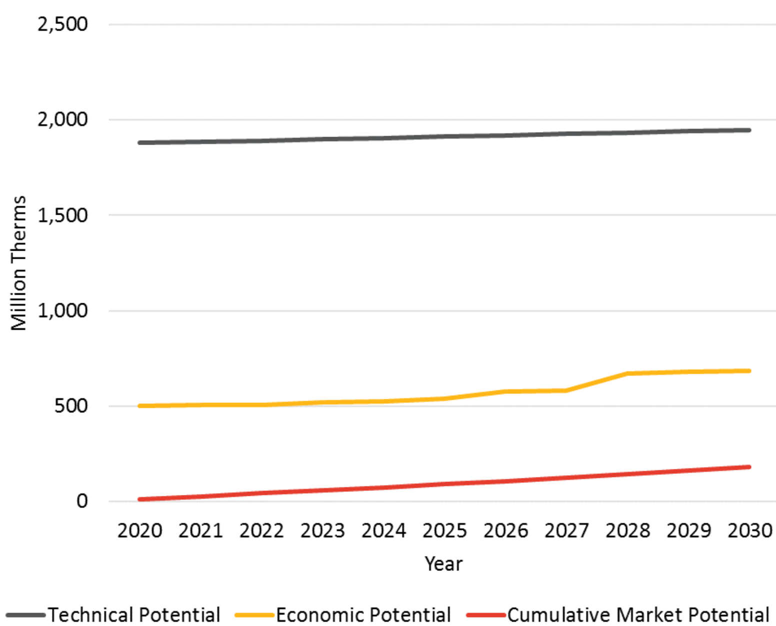


**Figure B-9. Statewide Technical, Economic, and Cumulative Gas Market Potential for Equipment Rebate Programs (Alternative 3)**

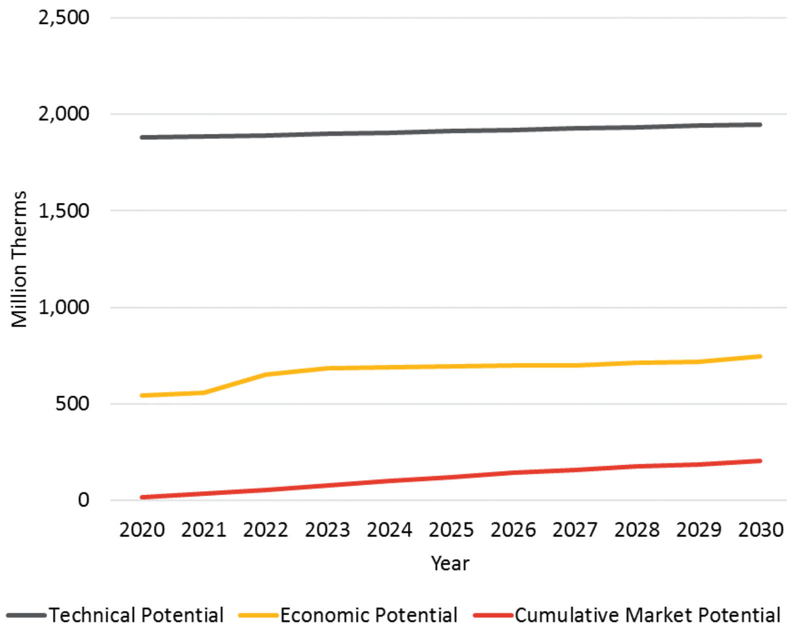
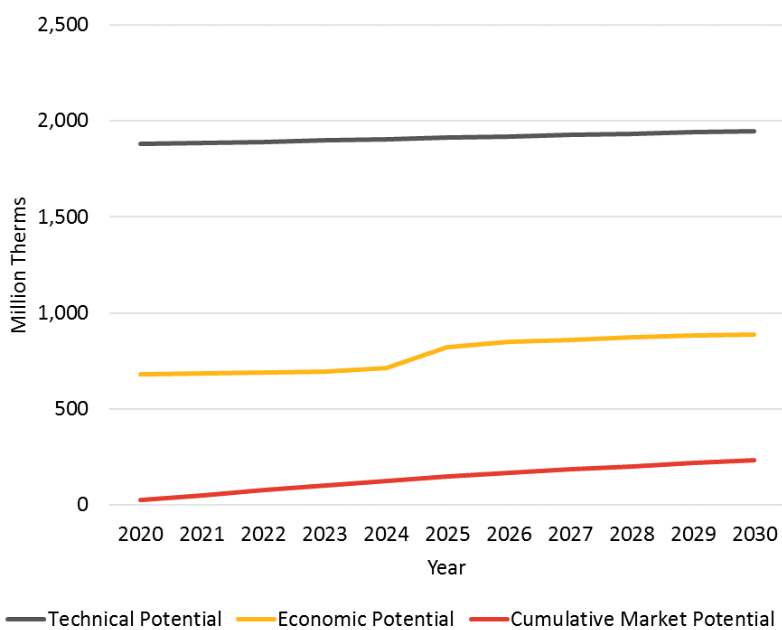



**Figure B-10. Statewide Technical, Economic, and Cumulative Gas Market Potential for Equipment Rebate Programs (Alternative 4)**



# APPENDIX C. BROS

This appendix discusses the BROs interventions that are included in the PG Model. It describes each intervention and discusses data sources and assumptions. A separate spreadsheet is also made available for stakeholders to review the final detailed inputs for intervention specific to each utility and building type.

## C.1 Residential – HERs

### *C.1.1 Summary*

Home energy reports (HERs) are among the most prevalent and widely studied of behavioral interventions. Residential customers are periodically mailed HERs that provide feedback about their home's energy use, including normative comparisons to similar neighbors, tips for improving energy efficiency (EE), and occasionally messaging about rewards or incentives. HER programs are generally provided to customers on an opt-out basis, although utilities in other states have conducted opt-in programs.

Estimated electric savings range from 1.3% to 1.4%, while gas savings are 0.7% to 1.4%. Costs are set at \$0.06-\$0.10 per kWh and \$0.92-\$1.88 per therm.[80,81]

**Table C-1. HERs – Key Assumptions**

| Sector | Type | EUL Years | Savings | | Cost | | kW/kWh Savings Ratio |
|---|---|---|---|---|---|---|---|
| | | | kWh | therm | kWh | therm | |
| RES | HERs | 1 | 1.3% – 1.4% | 0.7% – 1.4% | \$0.06 – \$0.10 | \$0.92 – \$1.88 | 0.000096 – 0.000266 |

### *C.1.2 Assumptions and Methodology*

***Eligibility and Participation***

Although all targeted residential households may receive HERs as participants in an opt-out program, in practice, PG&E found that 0.5% of customers elect to opt out. For this reason, the Navigant team reduced applicability to 99.5% for single-family homes. Applicability for multifamily homes is further reduced to

[80] Cost for PG&E and SDG&E are split across electric and gas fuel types.

[81] DNV-GL, Impact Evaluation of 2014 San Diego Gas & Electric Home Energy Reports Program (Final Report), 04/01/2016, California Public Utilities Commission

89.5%, dropping another 10% to account for multifamily homes that do not have individual meters.[82] SCE provided data indicating that only 0.17% of its multifamily customers are master-metered, so the applicability in its territory remains higher, at 99.33%. Applicability factor applies to the targeted treatment population, our model assumes a separate control population is still required for evaluation purposes.

While participation rates in HER programs fluctuate over time due to program opt outs/attrition, customer moves, and changes in program implementation such as adding new waves, specific forecasts require details beyond those publicly available via 2017 IOU-filed Rolling Business Plans.[83] For this reason, the team reviewed all formal California IOU evaluations of HER programs to ascertain historic HER program participation rates and wave sizes and then applied a weighted average of IOU wave sizes to forecast the

[82] Kate Johnson and Eric Mackres, Scaling up Multifamily Energy Efficiency Programs: A Metropolitan Area Assessment, Report Number E135, March 2013, American Council for an Energy Efficient Economy, from http://www.prezcat.org/sites/default/files/Scaling%20up%20MF%20Energy%20Efficiency%20Programs_0.pdf

[83] PG&E, Application of Pacific Gas and Electric Company for Approval of 2018-2025 Rolling Portfolio Energy Efficiency Business Plan and Budget, Public Utilities Commission of the State of California, January 17, 2017

SCE, Southern California Edison Company's Energy Efficiency Rolling Portfolio Business Plan Application, Statewide Administration Approach, Public Utilities Commission of the State of California, January 17, 2017

SDG&E, Application of San Diego Gas & Electric Company (U 902-M) to adopt Energy Efficiency Rolling Portfolio Business Plan Pursuant to Decision 16-08-019, Public Utilities Commission of the State of California, January 17, 2017

SCG, Energy Efficiency Business Plan for Southern California Gas Company, Public Utilities Commission of the State of California, January 17, 2017 future cohort waves according to the number of households within a given service territory.[84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98]

The forecast is further informed by the following considerations:

- SCG indicated that they would not deploy a HER program until 2018,[99] and that it would ramp up over 3 years.[100]
- A cap was placed on the penetration of HERs based on feedback that the bottom quartile of energy consumers will not be targeted and an equal number of customers need to be reserved as a control group for evaluation purposes.

The behavioral model then applies these projected penetration rates to the number of forecast IOU households, which increases over time from 2016 to 2030, resulting in an increase in the absolute number of actual HER participants over time.

***Savings***

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[84] DNV GL, Review and Validation of 2014 Pacific Gas & Electric Home Energy Reports Program Impacts (Final Report) 04/01/2016, California Public Utilities Commission, page 4, 19

[85] DNV GL,2013 PG&E Home Energy Reports Program Review and Validation of Impact Evaluation ED Res 3.1, April 06, 2015, California Public Utility Commission

[86] DNV KEMA, Review of PG&E Home Energy Reports Initiative Evaluation, 5-31-2013, CPUC Energy Division

[87] Freeman Sullivan and Company, Evaluation of Pacific Gas and Electric Company's Home Energy Report Initiative for the 2010–2012 Program, April 25, 2013, Pacific Gas and Electric Company, p 8, 26-31

[88] DNV GL, Review and Validation of 2014 Southern California Edison Home Energy Reports Program Impacts (Final Report) 04/01/2016, California Public Utilities Commission, page 3, 13

[89] DNV GL, 2013 SCE Home Energy Reports Program Review and Validation of Impact Evaluation ED Res 3.2, April 06, 2015, California Public Utilities Commission, p 3, 8

[90] August 2015 Advanced Metering Semi-Annual report provided by SCG staff. Appendix E - Nexant, Evaluation of Southern California Gas Company's 2015-2016 Conservation Campaign, August 2016, August 31, 2016, page E3

[91] DNV GL, Impact Evaluation of 2014 San Diego Gas & Electric Home Energy Reports Program (Final Report), 04/01/2016, California Public Utilities Commission, page 3, 24

[92] DNV GL, SDG&E Home Energy Reports Program 2013 Impact Evaluation ED Res 3.3, October 17, 2014, California Public Utility Commission

[93] 2. DNV GL. May 5, 2017. Review and Validation of 2015 Southern California Edison Home Energy Reports Program Impacts (Final Report). California Public Utilities Commission, May 5, 2017. CALMAC Study ID: CPU0156.01.

[94] 1. DNV GL. May 5, 2017. Review and Validation of the Pacific Gas & Electric Home Energy Reports Program Impacts (Final Report). California Public Utilities Commission, May 5, 2017. CALMAC Study ID: CPU0155.01.

[95] 3. DNV GL. May 5, 2017. Impact Evaluation of 2015 San Diego Gas and Electric Home Energy Reports and Manage Act Safe Programs (Final Report). California Public Utilities Commission, May 5, 2017. CALMAC Study ID: CPU0157.01.

[96] 4. PG&E.2017. RTR for the Review and Validation of 2015 Pacific Gas and Electric Home Energy Reports Program Impacts (Final Report) (DNV GL, Calmac ID #CPU0155.01,ED WO #ED_D_Res_3). California Public Utilities Commission, 2017. Calmac ID: CPU0155.01.

[97] 5. SCE. 2017. RTR for the Review and Validation of 2015 Southern California Edison Home Energy Reports Program Impacts (Final Report) (DNV GL, Calmac ID #CPU0156.01). California Public Utilities Commission, 2017. Calmac ID: CPU0156.01.

[98] 6. SDG&E. 2017. RTR for the Impact Evaluation of 2015 San Diego Gas & Electric Home Energy Reports and Manage-Act-Save Programs (Final Report) (DNV GL, Calmac ID #CPU0157.01). California Public Utilities Commission, 2017. Calmac ID: CPU0157.01.

[99] Informal comments on the webinar presented on April 20, 2017.

[100] Comments of Southern California Gas Company on Proposed Decision Adopting Energy Efficiency Goals for 2018 – 2030.

The Navigant team reviewed the above-mentioned evaluations of all IOU HER programs to compile per-household adjusted savings rates for each wave of each year of each HER program, spanning from 2011 to 2015, depending upon each utility's first year of operation.[101,102] The team then calculated weighted averages using each individual wave treatment participation numbers and per household savings percentages to derive singular values for kWh and therm savings that can be applied across the full treatment populations for each utility. Informal comments from stakeholders suggest that future HER customers will save less energy on average than current waves because the customers with the highest potential for savings are already leveraged in current HER programs.[103] To account for this, the overall growth rate in HER savings has been reduced over the forecast period. This is done in a stepwise fashion to approximate diminishing savings correlated with the growth of the program.

Model inputs were further calibrated to align with the PY2017 HERS impact evaluation issued by the CPUC. The impact evaluation reported savings for PY2017 as summarized in the table below.[104]

**Table C-2. Summary of Evaluated Impacts for 2017 HERS Programs**

| Utility | Adjusted Electric Savings (GWh) | Adjusted Gas Savings (MMTherms) |
|---|---|---|
| PG&E | 122.0 | 3.9 |
| SCE | 94.0 | - |
| SDG&E | 39.4 | 0.9 |
| **Total** | **255.4** | **4.8** |

Note: SCG was specifically excluded from the impact evaluation

The model uses an EUL of 1 year for HER program participants. That is, while customers may participate in a utility HER program for more than 1 year, their average adjusted savings are assumed to be the same as for all other participants in that year. While some recent evaluations of HERs programs have found savings persistence of more than 1 year, reported savings percentages vary, with some sources citing higher later year savings and others showing a degradation of savings over time. For this model, an EUL of 1 year is assumed, as is standard with traditional persistence calculations for HER programs.

The ratio of kW to kWh savings was developed using a weighted average of adjusted kW and kWh savings as reported in the above-mentioned DNV GL 2017 evaluation findings for PG&E, SDG&E and SCE. This ratio was then updated based on California hourly load profiles to align with the 2019 DEER peak period definition.[105]

***Cost***

[101] KEMA, SDG&E Home Energy Reports Program Savings Results, August 23, 2013, San Diego Gas and Electric

[102] Southern California Gas Company, 2013 Program Implementation Plan, California Public Utility Commission, sourced from http://eestats.cpuc.ca.gov/EEGA2010Files/SCG/PIP/2013/Clean/1.3%20Energy%20Advisor%20Attachment.pdf

[103] Stakeholder comments (PG&E, SCG, SCE, PAO) from May 9th, 2019 stakeholder meeting.

[104] DNV GL. May 1, 2019. Impact Evaluation Report: Home Energy Reports – Residential Program Year 2017. California Public Utilities Commission. CALMAC Study ID: CPU0194.01.

[105] California Public Utilities Commission (CPUC). Resolution E-4952, October 11, 2018. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M225/K049/225049353.PDF

Costs per unit of kWh and therm savings were based on California Energy Data and Reporting System (CEDARS) for program years 2017 and 2019 as available.[106] These costs were distributed to the kWh and therm savings (weighted by savings) as reported in the CEDARS database. The Energy Adviser costs sourced from the CEDARS database are an aggregate of home energy report and online audit tool costs.

## C.2 Residential – Universal Audit Tool

### *C.2.1 Summary*

The Universal Audit Tool (UAT) is an opt-in online tool that asks residential customers questions about their homes, their use of household appliances, and occupancy patterns and then it offers EE advice regarding ways they can save money and energy. The UAT is provided by all four of California's investor owned utilities. While each utility has its own branding, and some utilities require customers to log in while others do not, on the whole their features and functionality are similar. All four tools enable customers to develop plans to save energy based on estimates of the annual savings they are likely to see if the enact the recommended energy-saving advice.

There is some danger of double-counting UAT savings with other program savings such as HERs.[107] The DNV GL study used to characterize savings specifically addresses this potential and "find[s] no evidence of joint savings between the UAT and HER programs."[108]

Estimated electric savings range from 1.2-1.8%, while gas savings are 1.5-2.6%. Costs are set at $0.06 - $0.14 per kWh and $1.15 -$4.02 per therm. For low income customers costs range from $0.11 -$0.47 per kWh and $3.73 -$7.78 per therm.

**Table C-3. UATs – Key Assumptions**

| Sector | Type | EUL Years | Savings | | Cost | | kW/kWh Savings Ratio |
|---|---|---|---|---|---|---|---|
| | | | kWh | therm | kWh | therm | |
| RES | UAT | 1 | 1.2 - 1.8% | 1.5 - 2.6% | $0.01 - $0.02 | $0.18 - $0.38 | 0.000096 – 0.000266 |
| RES – Low Income | UAT | 1 | 1.2 - 1.8% | 1.5 - 2.6% | $0.01 - $0.02 | $0.18 - $0.38 | 0.000096 – 0.000266 |

### *C.2.2 Assumptions and Methodology*

[106] "Energy Adviser" programs savings and costs, California Energy Data and Reporting System (CEDARS). 2017 (PG&E, SCE, SDG&E); 2019 (SCG).

[107] Stakeholder comments from May 9th, 2019 stakeholder meeting.

[108] 7. DNV GL. March 31, 2017. Universal Audit Tool Impact Evaluation-Residential: California Public Utilities Commission, March 31, 2017. CALMAC ID: CPU0160.01.

### *Eligibility and Participation*

All residential customers of the four IOUs are eligible to use the UAT. Customers can access the tool after sign up for online services through their utility's My Energy or Energy Advisor web portals. Moreover, as with the HERs forecast, the Navigant team reduced the applicability for multifamily homes by 10% to account for multifamily homes that do not have individual meters.

According to a 2017 evaluation of the UAT by DNV GL,[109] over the years the tools have been active the number of customers has grown. Customer engagement and online survey completion vary by IOU, as does the associated level of marketing effort to drive customers to participate or re-participate for deeper savings. To forecast participation levels for the 2020 model the team relied on the participation numbers reported in the DNV GL evaluation to establish cumulative treatment sizes and then determined saturation levels based on the number of households per utility. Because evaluated participation rates were not available for SCE in reviewed sources, this value was calculated using an average percentage of saturation from the other California electric utilities. Starting saturation rates for early model years range from 0.5% to 0.8% and grow at compound growth rate of 12% per year, topping out at between 2.5% and 3.9% participation by 2030.

### *Savings*

The team relied on the above-mentioned 2017 DNV GL evaluation of the UAT to set per-household adjusted kWh and therm savings values for participating customers at each utility. Because evaluated kWh savings were not available for SCE, a rate of 1.2% kWh savings was applied since it was equivalent to the evaluated savings for PG&E, which was more conservative than the higher percentage of evaluated savings for SDG&E.

The model uses an EUL of 1 year for UAT participants. That is, while customers may participate in a utility UAT for more than 1 year, their average adjusted savings are assumed to be the same as for all other participants in that year. For this model, an EUL of 1 year is assumed, as is standard with traditional persistence calculations for residential behavior programs.

Because evaluated demand savings data was unavailable for UAT participants the team applied the figure used for HERs for all three electric utilities.

### *Cost*

Costs per unit of kWh and therm savings were based on CEDARS.110 These costs were distributed to the kWh and therm savings (weighted by savings) as reported in the CEDARS database. The Energy Adviser costs sourced from the CEDARS database are an aggregate of home energy report and online audit tool costs. The majority of the Energy Adviser costs are assumed to be associated with HERs; 20% of the Energy Adviser costs are attributed to the UAT costs.

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[109] 7. DNV GL. March 31, 2017. Universal Audit Tool Impact Evaluation-Residential: California Public Utilities Commission, March 31, 2017. CALMAC ID: CPU0160.01.

[110] "Energy Adviser" programs savings and costs, California Energy Data and Reporting System (CEDARS)

# C.3 Residential – Real-Time Feedback: In Home Displays and Online Portals

## *C.3.1 Summary*

Unlike HERs that arrive in the mail on a periodic basis, real-time feedback programs change customer behaviors by delivering advanced metering data on household consumption to utility customers via an in-home display (IHD) or remotely via an online portal, such as a website or a smartphone application. While some feedback programs only provide information, others provide energy saving tips, rewards, social comparisons, and/or alerts.

Although utility behavior programs utilizing IHDs and online portals both afford feedback opportunities, the Navigant team has separated its modeling inputs for the two categories to better capture differences in adoption, energy savings, and costs between the two types of programs. Of note is the higher cost typically associated with offering IHDs, due to the need for the installation of specialized hardware, whereas online portals typically provide cloud-based information directly to the customer's smartphone, tablet, or computer.

Real-time feedback programs may also be associated with different customer rates, including time of use plans and more traditional usage based billing. Although real-time feedback is a popular behavioral intervention for demand response (DR) programs, our analysis focused on programs designed to drive EE. In all, the Navigant team reviewed a total of 38 programs, including 20 providing IHDs and 18 offering online portals. Several programs offered both types of feedback. In those cases, the team categorized them in the IHD category since they had associated costs for the hardware.

**Table C-4. Real-Time Feedback - Key Assumptions**

| Sector | Type | EUL Years | Savings | | Cost | | kW/kWh Savings Ratio |
|---|---|---|---|---|---|---|---|
| | | | kWh | therm | kWh | therm | |
| RES | Real-Time Feedback – In Home Display | 1 | 2.3% | -- | $0.19 | -- | 0.000224 |
| RES | Real-Time Feedback – Online Portal | 1 | 2.2% | 1.3% | $0.07 | -- | 0.000224 |

## *C.3.2 Assumptions and Methodology*

***Eligibility and Participation***

Both web-based and IHD real-time feedback programs are offered on an opt-in basis to customers with smart-meter equipped homes. Although most residential feedback programs are focused on providing information about electricity consumption, some natural gas savings result from these programs which are likely the result of tips and recommendations concerning thermostat settings. For modeling purposes, the team assumes 100% applicability for electric savings among individually metered homes and 59% applicability for gas. This latter figure is conservative given that 59% of California households use natural gas as their main source of space heating and 84.4% of California homes use natural gas for water heating.[111]

IHDs did not pass the C-E screen, and so are not included in the reference case. SCE indicated they would not deploy these programs until 2019, and they would still only be pilots at that time.[112] This assumption was used for all utilities. The team assumes penetration rates for programs that use online portals to display customer information will be higher than those that rely on IHDs. For online portals, our reference case assumes an 8% increase in penetration per year, while the aggressive case assumes a 15% annual increase, based on professional judgement. PG&E provided penetration rate data for IHDs.[113]

***Savings***

Savings forecasts differ for online portals and IHDs. For online portals, the Navigant team estimates 1.3% savings for both kWh and therms. For IHDs, the team estimates 2.3% savings for kWh and no gas savings. These estimates were developed based on numerous data points for kWh savings.[114,115,116,117,118,119]

The model uses an EUL of 1 year, the same as the team applies for HER program participants. Because insufficient demand savings data was available for real time feedback for non-DR programs, for ratio of kW to kWh for HERs is used for all three electric utilities.

***Cost***

Hardware acquisition and installation constitute the primary cost associated with IHD programs, and they are accrued during the first year of customer participation. Sometimes these costs are paid by the utility, and other times by the customer. For modeling purposes, the team assumed that the utilities will provide

111 U.S. EIA Residential Energy Consumption Survey (RECS). “Table CE2.5 – Household Site Fuel Consumption in the West Region, Totals and Averages.” (2009). Available at: http://www.eia.gov/consumption/residential/data/2009/index.php?view=consumption#fuel-consumption

112 Informal comments on the webinar presented on April 20, 2017.

113 Ibid.

114 Kira Ashby, 2016 Behavior Program Summary, 2016, Consortium for Energy Efficiency, from https://library.cee1.org/content/2016-behavior-program-summary-public

115 Susan Mazur-Stommen and Kate Farley, ACEEE Field Guide to Utility-Run Behavior Programs, 2013, American Council for an Energy-Efficient Economy, from http://aceee.org/research-report/b132

116 Illume Advising, Energy Efficiency Behavioral Programs: Literature Review, Benchmarking Analysis, and Evaluation Guidelines, Conservation Applied Research & Development (CARD) FINAL REPORT, Prepared for: Minnesota Department of Commerce, Division of Energy Resources, May 4, 2015

117 Ben Foster and Susan Mazur-Stommen. 2012. “Results from Real-Time Feedback Studies.” American Council for an Energy Efficient Economy. Report Number B122

118 Reuven Sussman and Maxine Chikumbo. 2016. “Behavior Change Programs: Status and Impact.” American Council for an Energy Efficient Economy. Report Number B1601

119 Opinion Dynamics. “PY2013-2014 California Energy Efficiency and Demand Response Residential Behavior Market Characterization Study Report: Volume 1. Prepared for the California Public Utilities Commission Energy Division. July 2015.

the hardware and that IHDs cost $100, annualized over 5 years – similar to the life of other consumer electronics.[120]

To calculate the cost, the Navigant team began with a 2014 report by the Alberta Energy Efficiency Alliance for the City of Calgary that notes the cost for a real-time direct feedback program are estimated to be about $0.07 per kWh saved not including the hardware.[121] For IHDs, the team adds in the annualized $100 hardware acquisition and installation costs, resulting in $0.19 per kwh of savings (assuming 7,000 kwh per household).

## C.4 Residential – Competitions: Large and Small

### *C.4.1 Summary*

Residential competitions are a behavioral intervention approach in which participants compete in energy-related challenges, events, or contests. The goal of such challenges is generally to reduce energy consumption either directly or by raising awareness, increasing knowledge, or encouraging one or more types of action. Competitions can run for different lengths of time, ranging from a single month to multiple years. They can also include a mix of behavioral strategies, including goal-setting, commitments, games, social norms, and feedback. Our analysis does not include competitions and challenges that focus on the use of equipment upgrades as a means of generating energy savings.

It is also important to note that the way in which competitions are designed can vary depending upon the size of the targeted participant group. Small-scale competitions are typically designed to engage participants more deeply, with a higher number of touches and a broad spectrum of targeted behaviors that generate higher savings and serve as a model to get the larger population engaged. Large-scale competitions engage greater numbers of people in a more superficial way and encourage a limited number of behaviors. For this reason, the team separates its modeling calculations to estimate the savings for the two types of competitions separately.

The Navigant team defines small competitions as having less than 10,000 participants per year and large competitions as having more than 10,000 participants per year. In total, the team reviewed 18 small competitions and five large competitions. Data availability varied across programs.

**Table C-5. Residential Competitions - Key Assumptions**

| Sector | Type | EUL Years | Savings | | Cost | | kW/kWh Savings Ratio |
|---|---|---|---|---|---|---|---|
| | | | kWh | therm | kWh | therm | |
| RES | Small Competitions (<10,000 ppl) | 1 | 8.1% | 5.2% | $0.050 | $1.344 | 0.000224 |
| RES | Large Competitions (>10,000 ppl) | 1 | 14% | 5.2% | $0.002 | $0.101 | 0.000224 |

[120] PG&E provided this reference in response to the webinar on April 20: https://www.amazon.com/Rainforest-Energy-Monitor-ZigBee-Gateway/dp/B00AII248U

[121] Alberta Energy Efficiency Alliance, Energy Savings through Consumer Feedback Programs, Feb 2014, City of Calgary

### C.4.2 Assumptions and Methodology

**Eligibility and Participation**

All residential customers are considered eligible to participate in competitions. The estimated participation rate of 6.5% for small competitions was determined by averaging available reported participation rates. Participation data for small-scale competitions was derived from SDG&E's Biggest Energy Saver program, SMECO's Energy Savings Challenge, and Minnesota Valley Electric Cooperative's Beat The Peak program.[122] CoolChallenge California[123] provided a participation rate of 0.1% for large competitions. This information was supplemented with findings from program reviews conducted by the Consortium for Energy Efficiency,[124] American Council for an Energy-Efficient Economy,[125] and Illume Advising.[126]

Penetration rates for the reference case assume that small competitions are conducted by each utility with a consistent target population of 10,000 households per year each year between 2019 and 2030. Starting saturation level is determined by dividing 10,000 by the number of residential households per utility and multiplying by the 6.5% participation rate. The aggressive case also starts in 2019. It assumes that years 2019-2021 are limited to two target groups of 10,000, but then increased to 5 target groups of 10,000 each in subsequent year. These groups may be small towns, neighborhoods within larger cities, or similar.

Penetration rates for large competitions are based upon the participation rate and a targeted percentage of utility households. The reference case for large competitions assumes that each utility targets 10% of its residential customers between 2019 and 2021; then rises to 15% of customers from 2022 to 2024 before increasing to 20% in 2025 and rising to 25% of customers in 2028. The aggressive case uses the same time intervals, but it starts at 20% of customers and rises in increments of 10% rather than the 5% of the reference scenario.

**Savings**

The team averaged the percentage of kWh savings reported to arrive at 8.1% for small competitions and CoolCalifornia Challenge reported 14% for large competitions.[127] Gas savings of 5.3% are used for both

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[122] Grossberg, Frederick; Wolfson, Mariel; Mazur-Stommen, Susan; Farley, Kate; and Steven Nadel. 2015.(February) "Gamified Energy Efficiency Programs." ACEEE Report B1501.

[123] PG&E provided the following reference: Jones, Christopher M. and Kammen, Daniel M. 2014 "The CoolCalifornia Challenge: A Pilot Inter-City Household Carbon Footprint Reduction Competition." Contract Number: 10-325, California Air Resources Board. https://www.arb.ca.gov/research/apr/past/10-325.pdf

[124] Kira Ashby, 2016 Behavior Program Summary, 2016, Consortium for Energy Efficiency, from https://library.cee1.org/content/2016-behavior-program-summary-public

[125] Susan Mazur-Stommen and Kate Farley, ACEEE Field Guide to Utility-Run Behavior Programs, 2013, American Council for an Energy-Efficient Economy, from http://aceee.org/research-report/b132

[126] Illume Advising, Energy Efficiency Behavioral Programs: Literature Review, Benchmarking Analysis, and Evaluation Guidelines Conservation Applied Research & Development (CARD) FINAL REPORT, Prepared for: Minnesota Department of Commerce, Division of Energy Resources, May 4, 2015.

[127] PG&E provided the following reference: Jones, Christopher M. and Kammen, Daniel M. 2014 "The CoolCalifornia Challenge: A Pilot Inter-City Household Carbon Footprint Reduction Competition." Contract Number: 10-325, California Air Resources Board. https://www.arb.ca.gov/research/apr/past/10-325.pdf

small and large competitions and are based on an average of an ACEEE review of three programs that report gas savings between 0.4% and 10%.[128]

Because competitions can be run for different lengths of time, lasting from a few months to multiple years, the team standardized the model on an EUL of 1 year. (This is the same EUL that we apply for other residential interventions.) Because insufficient demand savings data was available for residential competitions, the team applied the ratio used for HERs for all three electric utilities.

***Cost***

Costs associated with competitions are largely associated with program administration and game-related prizes. Navigant used data gathered from the 2015 ACEEE's report on EE and gamification and information from the CEE database of behavioral programs to create cost estimates for both small and large behavior-based competitions. The team approached the calculations for both small and large competitions in the same way. The Navigant team began by estimating total program costs and total program savings and then divided total program costs by total program savings to get average cost per kWh. The team estimated total program savings by multiplying the average number of participants per competition by the cost per participant. The team estimated total program savings by multiplying average household electricity consumption by the average number of participants and the average savings rate per participant.

The Navigant team assumes that prizes account for 50% of program costs. The team estimated the cost per kWh at $0.007 for large competitions, based on the prizes and participation reported for SDG&E's San Diego Energy Challenge and Puget Sound Energy's Rock the Bulb program. The team estimated the cost per kWh at $0.050 for small competitions based on the prizes and participation reported for SMECO's Energy Savings Challenge and Minnesota Valley Electric Cooperative's Beat The Peak program.[129]

## C.5 Commercial – Strategic Energy Management

### *C.5.1 Summary*

Strategic energy management (SEM) is a process for evaluating and implementing opportunities to optimize energy use in the commercial and industrial sectors. SEM is a continuous improvement approach that focuses on changing business practices to enable companies to save money by reducing energy consumption and waste. In California, pilot SEM programs are currently being administered in the industrial sectors. Customers that benefit the most from SEM, typically fall under one of the following categories:

- Campuses with multiple buildings and building types
- Customers with a large portfolio of buildings and a range of building types

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[128] Grossberg, Frederick; Wolfson, Mariel; Mazur-Stommen, Susan; Farley, Kate; and Steven Nadel. 2015.(February) "Gamified Energy Efficiency Programs." ACEEE Report B1501.

[129] Grossberg, Frederick; Wolfson, Mariel; Mazur-Stommen, Susan; Farley, Kate; and Steven Nadel. 2015.(February) "Gamified Energy Efficiency Programs." ACEEE Report B1501.

- Buildings with complex energy systems

SEM allows for continuous energy performance improvement by providing the processes and systems needed to incorporate energy considerations and energy management into daily operations. While SEM applications vary depending on customer specific needs, program participants generally implement the following policies and activities:

- Measure and track energy use to help inform strategic business decisions
- Drive managerial and corporate behavioral changes around energy
- Develop the mechanisms to track and evaluate energy optimization efforts
- Implement ongoing operations and maintenance practices
- Reduce total annual energy costs between 5% and 10%
- Identify and prioritize capital improvements or process changes that lead to more savings
- Justify additional resources to energy management as a result of demonstrated success
- Overcome barriers to efficiency
- Boost employee engagement to contribute to sustainability goals
- Embed SEM principles into a company's operations.

The model inputs for electric and natural gas shown in the table below represent savings associated with operational and behavioral changes. Savings are estimated at 3% of customer segment consumption (kWh or therms per year) and are applied consistently by building and fuel type across utilities. Costs for electricity and natural gas are $0.27 per kWh and $3.65 per therm, and are also applied consistently by building type across utilities.

**Table C-6. Commercial SEM – Key Assumptions**

| Sector | Type | EUL Years | Savings | | Cost | | kW/kWh Savings Ratio |
|---|---|---|---|---|---|---|---|
| | | | kWh | therm | kWh | therm | |
| COM | Strategic Energy Management | 5 | 3.0% | 3.0% | $0.27 | $3.65 | 0.000102 |

## C.5.2 Assumptions and Methodology

***Eligibility and Participation***

Segments of the commercial market are considered suitable for SEM type program approaches. Customers that benefit the most from SEM typically operate portfolios or campuses with multiple buildings, building types, and a variety of complex energy systems, each with its own unique set of energy management requirements. The market defined for the 2019 Study therefore includes the following segments:

- Schools

- Colleges
- Healthcare
- Large Office Buildings

Depending on the segment, the model assumes that between 10% and 55% of buildings have already implemented SEM,[130] resulting in reduced applicability of any commercial SEM program. After accounting for the estimate of customers that have already implemented SEM outside of any program intervention, the 2019 Study applies an applicability factor of between 45% and 90%. A compound annual growth rate (CAGR) was used to forecast growth in participation over time, starting in 2020.[131] A 2% CAGR was used in the reference case, while the aggressive case used a 4% CAGR. Because current SEM penetration in the market segments studied is low, it is expected that these CAGRs will achieve segment penetrations by 2030 of approximately 1.2% for the reference case and 1.5% for the aggressive case.

***Savings***

Estimated electric savings for all activities associated with SEM range from 5% to 10% of customer segment consumption for electricity and gas (kWh or therms per year). These savings estimates include a mix of operational savings and savings associated with capital investments (i.e., equipment retrofit and replacement projects). Because savings from capital investments are addressed in other components of the potential model, the SEM savings associated with BROS activities are constrained to estimates of operational savings. Based on a literature review of 16 institutional SEM plans, such as the LW Hospitals Alliance 2014 plan,[132] and market studies such as the Northwest Energy Efficiency Alliance (NEEA) Market Progress Evaluation Report,[133] operations and maintenance savings are estimated to be 3% applied consistently by building and fuel type across all utilities for the market segments considered.

The model uses an EUL of 5 years.[134] A ratio of 0.000102 kW to kWh was applied to all three electric utilities based on an analysis of several third-party programs operating in California during the 2014-2015 portfolio cycle that included some components of SEM initiatives. This ratio was then updated based on California hourly load profiles to align with the 2019 DEER peak period definition.[135] The EUL and kW to kWh ratio before peak period modification are consistent with the 2017 Study.

***Cost***

Consistent with the 2017 Study, costs for electricity and natural gas savings in the 2019 Study are estimated at $0.27 per kWh and $3.65 per therm, applied consistently by building and fuel type across utilities based on an analysis of several third-party programs operating in California during the 2014-2015

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[130] Healthcare participation estimates are based on the 'Hospitals and Healthcare Initiative Market Progress Evaluation Report 7, Northwest Energy Efficiency Alliance. March 26, 2015. REPORT #E15-310. Participation estimates for other market segments are based on professional judgement.

[131] Informal comments in response to the webinar held April 20, 2017.

[132] Joint Strategic Energy Management Plan for Listowel Wingham Hospitals Alliance, 2014

[133] Hospitals and Healthcare Initiative Market Progress Evaluation Report 7, Northwest Energy Efficiency Alliance. March 26, 2015. REPORT #E15-310

[134] Personal communication with Kay Hardy, CPUC. May 9, 2017.

[135] California Public Utilities Commission (CPUC). Resolution E-4952, October 11, 2018. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M225/K049/225049353.PDF

portfolio cycle that included some components of SEM initiatives, including the Commercial Energy Advisor, Monitoring-Based Persistence Commissioning, and Energy Fitness programs

## C.6 Commercial – Building Operator Certification

### *C.6.1 Summary*

Building operator certification (BOC) offers EE training and certification courses to commercial building operators in the commercial sector. BOC has been modeled as a component of behavioral savings in the 2011, 2013, and 2015 Potential Studies and research conducted for those studies indicate that operations and maintenance practices mostly fell into the following categories:[136]

- Improved air compressor operations and maintenance
- Improved HVAC operations and maintenance
- Improved lighting operations and maintenance
- Improved motors/drives operations and maintenance
- Water conservation resulting in energy savings
- Adjusted controls of HVAC systems
- Adjusted controls of energy management systems

The inputs for electric and natural gas shown in the table below represent savings associated with changes in operation and behavior, estimated on a population basis of 1,000 sq. ft. of floor space. Savings vary depending on the energy intensity of facilities in each market segment[137] and IOU from 153 kWh to 14 kwh for electricity, and as defined in the 2009 CEUS. EUL is set to 3 years per CPUC Decision 16-08-019, and costs for electricity and natural gas savings are $0.29 per kWh and $3.65 per therm sourced from EEStats data from 2013 through 2017. Cost and EUL values are applied consistently by building and fuel type across all utilities.

**Table C-7. Commercial Building Operator Training - Key Assumptions**

| Sector | Type | EUL Years | Savings (per 1,000 sq. ft.) | | Cost | | kW/kWh Savings Ratio |
|---|---|---|---|---|---|---|---|
| | | | kWh | therm | kWh | therm | |
| COM | BOC | 3 | 14-153 | 0.3-35.7 | $0.29 | $3.65 | 0.000092 |

[136] Analysis to Update Potential Goals and Targets for 2013 and Beyond, literature search results provided in Appendix C. Navigant Consulting Inc., March 19, 2012

[137] As defined in the California Energy Commission (CEC), California Commercial End-Use Survey, CEC-400-2006-005, Prepared by Itron, Inc., March 2006, Final report available at: http://www.energy.ca.gov/ceus/index.html. Data available at: http://capabilities.itron.com/ceusweb/.

### C.6.2 Assumptions and Methodology

#### Eligibility and Participation

Consistent with prior studies, BOC savings apply to all commercial market segments, though the applicability factor of BOC ranges from 5% to 100%, depending on the market segment. This model assumes that BOC program interventions in the commercial market have been ongoing (though SoCalGas does not claim savings until 2018) and a CAGR was used to forecast growth in participation through the model forecast horizon. In the reference case, a 12.5% CAGR was used to forecast growth in BOC, while the aggressive case used a 18.0% CAGR. While these growth rates appear ambitious, low initial sector engagement in BOC results in forecast market penetrations of 6.52% and 12.12% for the reference and aggressive cases, respectively. While there is the potential for overlap in savings between BOC and SEM interventions, the current saturation of these measures and relatively low penetration rate forecast indicate that the risk of double counting savings is minimal and was therefore was not considered in this model. SCG does not currently have a BOC program so participation is projected to begin in 2020 for this utility.

#### Savings

The method of calculating unit energy savings has changed over time and the 2019 Study uses the same approach and values used in the 2017 Study. For context, the 2015 Study used the same average electric and natural gas savings of 58 kWh and 5.6 therms per 1,000 sq. ft. of participating building space for all market segments.[138] The 2017 Study refined this approach and applied a market segment-specific UES value that accounted for differences in building energy density. For example, a grocery store with much higher energy densities than a warehouse would experience a proportionally greater savings rate per unit of conditioned space. In this example, a grocery store in PG&E territory is expected to save 151.3 kWh per 1,000 sq. ft. and 5.2 therms per 1,000 sq. ft., compared to an unrefrigerated warehouse, which would be expected to save 18.2 kWh per 1,000 sq. ft. and 0.8 therms per 1,000 sq. ft. after accounting for differences in energy density.

Consistent with the 2017 Study, the 2019 model uses an EUL of 3 years, per CPUC Decision 16-08-019, and a ratio of 0.000092 kW to kWh was applied to all three electric utilities. This value is based on an analysis of several third-party programs operating in California during the 2014-2015 portfolio cycle. This ratio was then updated based on California hourly load profiles to align with the 2019 DEER peak period definition.[139]

#### Cost

Costs for electricity and natural gas savings are estimated at $0.29 per kWh and $3.65 per therm, applied consistently by building type across utilities. These cost values did not change between the 2018 and 2020 studies.

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[138] Energy Efficiency Potential and Goals Study for 2015 and Beyond Stage 1. Final Report Section 3.7.1 Non-Residential Behavior Model Updates. Navigant Consulting Inc., September 25, 2015

[139] California Public Utilities Commission (CPUC). Resolution E-4952, October 11, 2018. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M225/K049/225049353.PDF

## C.7 Commercial – Building Energy and Information Management Systems

### *C.7.1 Summary*

The potential for building energy management and information systems (BEIMS) were first modeled by Navigant as part of the AB 802 Technical Analysis.[140] The Technical Analysis was issued in March of 2016 and not used at that time to set goals. That work has now been incorporated into the 2019 model.

As discussed in the Technical Analysis, BEIMS includes IT-based monitoring and control systems that provide information on the performance of various components of a building's infrastructure, including systems related to the envelope, heating and ventilation, lighting, plug load, water use, occupancy, and other critical resources. BEIMS infrastructure primarily consists of software, hardware (such as dedicated controllers, sensors, and submeters), as well as value-added services (including outsourced software management, building maintenance contracts, and others). This model focuses on the potential for BIEMS to change energy consumption associated with the operation of building HVAC systems as the result of several applications of BEIMS technology, including the following:

- Energy visualization
- Energy analytics
- Operational control and facility management
- Continuous commissioning and self-healing buildings.

The model inputs for electric and natural gas for BEIMS are shown in the table below based on customer segment consumption (kWh or therms per year). Electricity savings range from 1.1% to 4.2% and natural gas savings range from 0.2% to 7.4%. Variations are due to differences in segments' energy densities and differences in climate across utilities. Costs for electricity and natural gas savings also varied by utility between $0.20 and $0.46 per kWh and between $0.18 and $0.49 per therm.

**Table C-8. Building Energy and Information Management Systems - Key Assumptions**

| Sector | Type | EUL Years | Savings | | Cost | | kW/kWh Savings Ratio |
|---|---|---|---|---|---|---|---|
| | | | kWh | therm | kWh | therm | |
| COM | Building Energy and Information Management Systems | 3 | 1.1% - 4.2% | 0.2% - 9.3% | $0.20 - $0.44 | $0.18 – $0.49 | 0.000112 |

### *C.7.2 Assumptions and Methodology*

[140] AB802 Technical Analysis, Potential Savings Analysis. Navigant Consulting, Inc., Reference No.: 174655. March 31, 2016

***Eligibility and Participation***

The technologies that enable BEIMS are primarily associated with energy management systems (EMS) that are broadly applicable across all market sectors, though the existing market saturation of these technologies, which cannot be claimed by IOU programs moving forward, ranges across market segments from 1% to 80%.[141] In general, segments that operate larger facilities (e.g., large offices) or facilities that are energy intensive (e.g., grocery stores) will have a higher existing saturation of BEIMS-enabling technologies. Penetration reflects that SoCalGas does not claim savings until 2018, and a CAGR was used to forecast growth in BEIMS technology penetration over time. A 12% CAGR was used in the reference case, while the aggressive case used a 24% CAGR. The same CAGR was applied to all commercial market segments and utilities. Based on estimates of market saturations as of 2017, these growth rates result in BEIMS forecast penetrations of 5.6% and 20.9% for the reference and aggressive cases, respectively by the end of the forecast horizon in 2030.

***Savings***

As discussed in the AB 802 Technical Analysis, unit energy savings (UES) associated with BEIMS are calculated using the following equation:

> *Unit Energy Savings, BIEMS = Starting Saturation of EMS by Building Type x Total Annual Consumption x % End Use Consumption for HVAC x % End Use Savings by Building Type.*

This equation resulted in a range of UES values associated with BEIMS. While there is the potential for overlap in savings between BEIMS, BOC, and SEM interventions, the current saturation of these measures and relatively low penetration rates forecast indicate that the risk of double counting savings is minimal and was therefore was not considered in this model. Additionally, BEIMS often requires capital investment while BOC and SEM are typically not capital investments, thus providing some differentiation in the market penetration models and potential to mitigate the risk of double counting savings. This UES, defined through work on the AB 802 Technical Analysis, is then used in the potential model to calculate annual segment level savings for each fuel type and IOU using the following equation:

> *Segment Savings, BIEMS = Segment UES x Penetration Rate x Total Annual Segment Consumption x Segment Applicability Factor.*

Consistent with the 2017 Study, the model uses an EUL of 3 years per CPUC Decision 16-08-019 and a ratio of kW to kWh of 0.000112 was applied to all three electric utilities as defined in the AB802 Technical Analysis.[142] This ratio was then updated based on California hourly load profiles to align with the 2019 DEER peak period definition.[143]

***Cost***

[141] AB802 Technical Analysis, Potential Savings Analysis. Navigant Consulting, Inc. Reference No.: 174655, March 31, 2016

[142] Ibid.

[143] California Public Utilities Commission (CPUC). Resolution E-4952, October 11, 2018. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M225/K049/225049353.PDF

Costs for electricity and natural gas savings are estimated based on research referenced in the AB 802 Technical Analysis.[144] The costs per unit of fuel savings were calculated for each utility and fuel type as shown in Table C-8.

**Table C-9. Building Energy and Information Management Systems Cost per Unit Energy Savings**

| Fuel | Utility | Cost |
|---|---|---|
| kWh | PG&E | $0.435 |
| kWh | SCE | $0.204 |
| kWh | SDG&E | $0.323 |
| kWh | SCG | NA |
| therms | PG&E | $0.340 |
| therms | SCE | NA |
| therms | SDG&E | $0.489 |
| therms | SCG | $0.180 |

## C.8 Commercial – Business Energy Reports

### *C.8.1 Summary*

Business energy reports (BERs) are the commercial sector equivalent to the HERs sent to residential customers. BERS (and other similar programs) typically share reports (via mail or electronic format) with small and medium sized businesses at specific intervals (often monthly). The objective is to provide feedback about their energy use, including normative comparisons to similar businesses, tips for improving EE, and occasionally messaging about rewards or incentives. BERs and other similar programs typically send reports to customers on opt-out basis. BER-type programs are a relatively new addition in the emerging field of behavior change programs and are now in pilot testing at PG&E and other non-California utilities.

Navigant's modeling estimates are primarily based on three sources: 1) PG&E's response to the webinar on April 20, 2017, 2) a Cadmus review of a BER pilot with Xcel Energy business customers (smaller than 250 kW service) in Colorado (10,000 participants) and Minnesota (20,000 participants) that was conducted between June 2014 and June 2015, and 3) a commercial customer behavior change pilot conducted by Commonwealth Edison and Agentis Energy in Illinois beginning in 2012. In the first instance, Xcel Energy provided BERs to a sample of businesses operating in the following sectors: small office, small retail trade, small retail service, and restaurants.[145] In the Commonwealth Edison pilot the utility engaged 6,009 medium sized (100-1,000 kW) commercial customers in Illinois.[146] While the

[144] Ibid.

[145] Jim Stewart, Energy Savings from Business Energy Feedback [for Xcel Energy], Cadmus, October 21, 2015, Behavior, Energy, and Climate Change Conference 2015

[146] Gajus Miknaitis, John Lux and Deb Dynako, Mark Hamann and William Burns, Tapping Energy Savings from an Overlooked Source: Results from Behavioral Change Pilot Program Targeting Mid-Sized Commercial Customers, 2014 ACEEE Summer Study on Energy Efficiency in Buildings, Commonwealth Edison and Agentis Energy, from: http://aceee.org/files/proceedings/2014/data/papers/7-153.pdf

Commonwealth Edison customers represented numerous sectors, only those businesses in the "lodging" and "other" categories showed significant savings.

**Table C-10. Business Energy Reports - Key Assumptions**

| Sector | Type | EUL Years | Savings | | Cost | | kW/kWh Savings Ratio |
|---|---|---|---|---|---|---|---|
| | | | kWh | therm | kWh | therm | |
| COM | BERs | 2 | 0.32% | - | $0.20 | $6.12 | 0.000102 |

### C.8.2 Assumptions and Methodology

***Eligibility and Participation***

BERs typically target small and/or medium sized businesses. In addition, utilities may use BERs to target businesses across all business sectors or only a select set of business sectors. As the number of BERs pilots continues to grow, a greater amount of information about the effectiveness of BERs programs in different business sectors will become available. As information concerning the effectiveness of these programs in different business sectors becomes more readily available, the team assumes that utilities will be more likely to limit the use of BERs to those sectors for which significant savings have been documented. Therefore, the model presented here constrains our savings estimates to those business sectors that have already achieved significant energy savings by means of business energy feedback programs such as BERs.

The model includes businesses in the following sectors: retail, restaurants, lodging, and "other." Within each of these business sectors, the applicability of savings is further constrained by the estimated proportion of business customers in each of the relevant sectors that may be classified as either small or medium sized enterprises (given that BER type programs are typically limited to small to medium sized businesses). Based on data from the Commercial Building Energy Consumption Survey (CBECS), we estimated that roughly 63% of retail customers can be considered to be small or medium businesses given that approximately 63% of retail space is shown to be under 100,000 square feet.[147] Given the small size of restaurants, we assume 100% applicability for this sector.

The Commonwealth Edison study specifically targeted medium sized businesses in the lodging and "other" sectors. Therefore, our savings estimates are only calculated for medium sized customers in the lodging and "other" categories based on relevant data from CBECS. For lodging, for example, we assume that 50% of lodging establishments can be considered medium sized establishments based on CBECS data indicating that 50% of lodging establishments have an average annual energy consumption of 500,000 kWh or more per year. For businesses in the "other" category, we look at CBECS data to estimate the proportion of establishments that fall in the medium sized category (<1 m kWh per year). We estimate that 25% of buildings in the "other" category are using an average of 400,000 kWh per year.

[147] U.S. Energy Information Administration, Commercial Building Energy Consumption Survey, http://www.eia.gov/consumption/commercial/data/2012/index.php?view=consumption#c13-c22

Our projected penetration rates assume a delayed start for BERs with formal utility programs launching in 2019. Our reference scenario assumes no penetration. Under the aggressive scenario, penetration begins at 2% in 2019 and ramps up at 2% per year, reaching 24% by 2030.

***Savings***

The model uses electricity savings of 0.32%, no gas savings,[148] and an EUL of 2 years per CPUC Decision 16-08-019. Because no demand savings data was available for BERs, we averaged the ratio of kW to kWh savings calculated for BEIMS, BOC, and SEM. This yielded 0.000102, which is the figure used for all four utilities.

***Cost***

Because BER programs are new and in pilot phases, data regarding utility costs is scant. Furthermore, the limited availability of statistically significant adjusted savings percentages reported to-date indicates that BER-related savings are lower among businesses than household savings produced by HERs. For these reasons, we modeled BER costs that are double those of HERs. We project \$0.20 per kWh (2 x \$0.10) for electric savings for PG&E, SCE, and SDG&E.

## C.9 Commercial – Benchmarking

### *C.9.1 Summary*

Building benchmarking scores a business customer's facility or plant and compares it to other peer facilities based upon energy consumption. It also often includes goal-setting and rewards in the form of recognition. Benchmarking is generally an opt-in activity, although some municipalities, such as San Francisco, have passed ordinances requiring it for buildings of certain types and sizes.

Estimated electric savings range from 0.4% to 1.6%, while gas savings are 0.3% to 1.0%. These are applied consistently across utilities, but vary by building type. Costs were estimated to be \$0.08 per kWh and \$0.37 per therm and are not utility specific.

**Table C-11. Benchmarking - Key Assumptions**

| Sector | Type | EUL Years | Savings | | Cost | | kW/kWh Savings Ratio |
|---|---|---|---|---|---|---|---|
| | | | kWh | therm | kWh | therm | |
| COM | Building Benchmarking | 2 | 0.4%-1.6% | 0.3%-1.0% | \$0.08 | \$0.37 | 0.000102 |

148 Informal comments on the webinar presented on April 20, 2017 from PG&E cite results of a trial that ran January to October in 2014.

### C.9.2 Assumptions and Methodology

**_Eligibility and Participation_**

In San Francisco, there is a benchmarking ordinance for any building over 10,000 sq. ft. According to the EIA, approximately 20% of all commercial buildings are under 10,000 sq. ft.[149] While any building and business type may be subject to benchmarking, reliable savings data exists for the following: colleges, healthcare, lodging, large offices, retail, and schools. For these sectors, we applied CBECS data to determine applicability.[150] For instance, we applied 100% applicability for both fuel types to colleges, while for retail we estimated 35% applicability since CBECS data indicates that roughly 35% of all retail buildings exceed 10,000 sq. ft. For healthcare, we used CBECS data to ascertain the proportion of electricity and natural gas consumed by large inpatient facilities. This information suggests that roughly 69% of all electricity and 83% of natural gas used in the healthcare sector is consumed by large healthcare facilities. School applicability is assumed to be 90% after a 10% reduction to account for smaller private learning centers.

There is uncertainty as to what extent the utilities will be able to claim savings from these initiatives if benchmarking is mandated by some level of government. Further, current building benchmarking mandates do not cover the full building population, thus leaving a segment of buildings in California with potential for benchmarking savings but no specified mandate to benchmark energy use. Due to these factors, building benchmarking is excluded from the reference scenario but included in the aggressive scenario. In the aggressive scenario, PG&E begins with 7.6% penetration, but then climbs to 15.1% in 2020 and 22.7% in 2025. The aggressive scenario penetrations for the other three utilities begin with 7.6% in 2019 and step up to 15.1% starting in 2024.

**_Savings_**

Estimated electric savings range from 1.1% to 2.2%, while gas savings range from 0.7% to 1.3% and are applied consistently by building and fuel type across utilities. Savings estimates are based on actual savings levels from city benchmarking reports.[151,152,153,154,155] We divided reported savings in half because we assume that half of the savings come from technologies and half from operation-related behaviors. Furthermore, we have applied a consistent split of 60% electric savings and 40% gas savings. This likely

[149] U.S. EIA. Commercial Building Energy Consumption Survey (CBECS) “Table B6. Building size, number of buildings, 2012.” (May 2016).

[150] U.S. EIA. Commercial Building Energy Consumption Survey (CBECS) “Table C1. Total energy consumption by major fuel, 2012.” (May 2016).

[151] SF Environment and ULI Greenprint Center for Building Performance. “San Francisco Existing Commercial Buildings Performance Report: 2010-2014.” (2015)

[152] Katherine Tweed. “Benchmarking Drives 7 Percent Cut in Building Energy. (October 2012) Greentech Media

[153] City of Chicago. “City of Chicago Energy Benchmarking Report 2016.”

[154] Jewel, Amy; Kimmel, Jamie; Palmer, Doug; Pigg, Scott; Ponce, Jamie; Vigliotta, David; and Weigert, Karen. “Using Nudges and Energy Benchmarking to Drive Behavior Change in Commercial, Institutional, and Multifamily Residential Buildings.” 2016. Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings.

[155] Navigant Consulting. “New York City Benchmarking and Transparency Policy and Impact Evaluation Report.” (May 2015). Prepared for the U.S. Department of Energy by Navigant Consulting, Inc., Steven Winter Associates, Inc., and Newport Partners, LLC.

varies by building type, but as these data were not available we have not made this calculation based on specific building-type consumption information.

The model uses an EUL of 2 years per CPUC Decision 16-08-019.

Because no demand savings data was available for Benchmarking, we averaged the ratio of kW to kWh savings calculated for BEIMS, BOC, and SEM. This yielded 0.000102, which is the figure used for all three electric utilities.

***Cost***

Available data suggest that benchmarking programs often include a utility in concert with a municipality. Our estimates used PG&E's estimated 3-year program budget of $2.3 million.[156] Attributing all costs to either electricity or gas, this utility program cost was divided by estimated savings to calculate a per unit savings cost. Costs amounted to $0.0396 per kWh and $0.2352 per therm and are not utility specific.

## C.10 Commercial – Competitions

### *C.10.1 Summary*

Commercial competitions are a behavioral intervention approach in which participants compete in events, contests, or challenges to achieve a specific objective or the highest rank compared with other individuals or groups as they try to reach goals by reducing energy consumption. Competitions can run for varying time periods ranging from a single month to multiple years. They can include a mix of behavioral strategies, including goal-setting, commitments, games, social norms, and feedback. Those designed to produce energy savings via equipment upgrades were not included in our analysis.

Competitions may be designed differently depending upon the size and nature of the targeted participant group. Smaller scale competitions are designed to engage people in a deep way with a higher level of touches and a broad spectrum of behaviors that generate higher savings and serve as a model to get the larger population engaged. Large scale competitions engage greater numbers of people in a more superficial way and encourage a limited number of behaviors. Because we had limited data for this type of behavioral intervention all commercial competitions are considered as a single category.

In additional to overall summary data available through the ACEEE[157] and the CEE,[158] we considered 10 different challenges, including the EPA's ENERGY STAR Building Competition, NEEA's Kilowatt

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[156] CPUC, Statewide Benchmarking Process Evaluation, Volume 1, CPU0055.01, Submitted by NMR Group and Optimal Energy, April 2012.

[157] Kira Ashby, 2016 Behavior Program Summary, 2016, Consortium for Energy Efficiency, from https://library.cee1.org/content/2016-behavior-program-summary-public

[158] Susan Mazur-Stommen and Kate Farley, ACEEE Field Guide to Utility-Run Behavior Programs, 2013, American Council for an Energy-Efficient Economy, from http://aceee.org/research-report/b132

Crackdown, Chicago's Green Office Challenge, and PG&E's Step Up and Power Down pilot.[159,160] The completeness of data available on each program varied with some of the most robust data coming from Duke Energy's Smart Energy Now effort in Charlotte, NC.[161]

**Table C-12. Commercial Competitions - Key Assumptions**

| Sector | Type | EUL Years | Savings | | Cost | | kW/kWh Savings Ratio |
|---|---|---|---|---|---|---|---|
| | | | kWh | therm | kWh | therm | |
| COM | Competitions | 2 | 1.9% | -- | $ 0.04 | -- | 0.000102 |

## *C.10.2 Assumptions and Methodology*

***Eligibility and Participation***

Eligibility for commercial competitions is defined by the program administrator. Competitions can focus on occupants within an individual building or across a single company, but more often they embrace wider audiences at the municipal level, in which groups of tenants within large buildings or across campuses or neighborhoods compete with one another. Nonetheless, certain business sectors and business types constitute more receptive customer types than others.

For this model, we focused on savings in those building types that have been targeted by PG&E's Step Up and Power Down campaign that is currently being carried out in San Francisco and San Jose. This effort is focused on the following five building types: large offices, small offices, retail, restaurants, and lodging.[162,163] The applicability factor was defined in terms of potential program reach as it applies to larger and smaller types of buildings. We assume an applicability of 8% for large offices and lodging and a lower applicability factor of 4% for small to medium businesses - small offices, restaurants, and retail.[164]

At the time this model was prepared, PG&E was the only California IOU running a commercial competition, but they were not claiming savings. Because of this, our penetration forecast for PG&E shows 0% until 2019, at which point we anticipate they will begin to claim savings for one city and hold steady through 2030. SCE and SDG&E do not begin claiming savings until 2021. We do not anticipate that SCG will run commercial competitions given that we currently do not have sufficient data with which

159 Edward Vine and Christopher Jones, A Review of Energy Reduction Competitions. What Have We Learned?, 2015 (May), California Institute for Energy and Environment. Report sponsored by the California Public Utilities Commission. Available at: http://escholarship.org/uc/item/30x859hv

160 Edward L. Vine and Christopher M. Jones. Competition, carbon, and conservation: Assessing the energy savings potential of energy efficiency competitions. 2016. Vol 19: 158-176. *Energy Research and Social Science*.

161 TecMarket Works, Impact Evaluation of the Smart Energy Now Program (NC) (Pilot) for Duke Energy, February 21, 2014.

162 Linda Dethman, Brian Arthur Smith, Jillian Rich, and James Russell. Engaging Small and Medium Businesses in Behavior Change through a Multifaceted Marketing Campaign. 2016. Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings.

163 Kat A. Donnelly. Workplace Engagement: Finding and Filling the Gaps for Fruitful Energy Savings. 2016 (October). Presentation at the 2016 Behavior, Energy and Climate Change Conference. Baltimore, MD.

164 Informal comments received in response to the webinar on April 20, 2017 from PG&E indicate a limited willingness to participate in commercial competitions.

to model gas savings. For the aggressive scenario, PG&E, SCE, and SDG&E all begin to claim savings in 2019, and in 2024, they add a second city-size competition.

The penetration rates for each utility assume that they will target the largest cities within their service territories, such as San Francisco, San Jose, Anaheim, and San Diego, or that groups of smaller communities - the size of Walnut Creek, Santa Barbara, or Oceanside - may be pooled together within a service territory to reach a similar number of businesses.

***Savings***

Savings estimates are based on PG&E's study of Step Up and Power Down (1.9% kWh). No gas savings are modeled.

The model uses an EUL of 2 years to maintain consistency with CPUC Decision 16-08-019.

Because no demand savings data was available, we averaged the ratio of kW to kWh savings calculated for BEIMS, BOC, and SEM. This yielded 0.000102, which is the figure used for all three electric utilities.

***Cost***

Costs of $0.04 per kWh are drawn from Smart Energy Now. [165]

## C.11 Commercial – Retrocommissioning

### *C.11.1 Summary*

The potential for retrocommissioning (RCx) was modeled as a component of behavioral savings in the 2013, 2015, and 2018 studies and this update refines several of the underlying assumptions and inputs used. RCx is defined as commissioning performed on buildings that have not been previously commissioned. This model also includes the allowed recommissioning of buildings that have undergone commissioning after 5 years have passed. The model focuses on RCx activities that impact HVAC system operations and includes, for example, measures such as the following:[166]

- Correct actuator/damper operations
- Correct economizer operations
- Adjust condenser water reset
- Adjust supply air temperature reset
- Adjust zone temperature deadbands
- Adjust equipment scheduling
- Adjust duct static pressure reset
- Adjust hot or cold deck reset

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[165] TecMarket Works, Impact Evaluation of the Smart Energy Now Program (NC) (Pilot) for Duke Energy, February 21, 2014.

[166] 2016 Statewide Retrocommissioning Policy & Procedures Manual, Version 1.0. Effective Date: July 19, 2016

- Optimize Variable Frequency Drives on fans or pumps
- Recode Controls HVAC airflow rebalance/adjust
- Reduce simultaneous heating and cooling
- Adjust boiler lockout schedule

The model inputs for electric and natural gas for RCx, shown in the table below, are based on customer segment consumption (kWh or therms per year). Electricity and natural gas savings range from 2.3% to 12.7%, and are applied consistently level for all utilities. Costs for electricity and natural gas savings are also constant across utilities at $0.39 per kWh and $0.29 per therm. Industry literature indicates that demand savings associated with RCx are minimal and the 2019 Study does not forecast demand savings for RCx, as such the kW/kWh savings ratio is 0.

**Table C-13. Commercial Retrocommissioning - Key Assumptions**

| Sector | Type | EUL Years | Savings | | Cost | | kW/kWh Savings Ratio |
|---|---|---|---|---|---|---|---|
| | | | kWh | therm | kWh | therm | |
| COM | RCx | 5 | 2.3% - 5.17% | 2.3% - 5.17% | $0.21 | $0.38 | 0.000112 |

### *C.11.2 Assumptions and Methodology*

***Eligibility and Participation***

Consistent with previous studies, RCx savings are applied to select commercial market segments, and the applicability factor ranges from 18% to 91%. Consistent with the 2017 Study, the 2019 Study also adjusted the eligibility and participation estimates for RCx to exclude BEIMS market potential, and to exclude buildings built after 2011 when commissioning became a requirement under CalGreen. It is estimated that approximately 92% of commercial building stock was constructed before 2011. The exclusion of market savings from BEIMS is intended to reduce the risk of double counting savings because the EMS technologies inherent in the BEIMS measure allow for continuous commissioning that would exclude commissioning activities defined in the RCx measure. The model assumes that RCx program interventions in the commercial market have been ongoing since the 2015 Study (though SoCalGas does not claim savings until 2018), and a CAGR was used to forecast growth in participation through the model forecast horizon. In the reference case, a 3,1% CAGR was used to forecast growth in RCx, while the aggressive case used a 4.5% CAGR. Recommissioning is anticipated in 25% of RCx participants after 5 years, and re-participation is additionally discounted by 25% to avoid double counting of savings influenced by other programs, such as BOC and SEM. Low initial penetration of RCx results in forecast penetrations of 2.3% and 2.8% for the reference and aggressive cases, respectively, over the forecast horizon.

***Savings***

Energy savings associated with RCx are calculated using the following equation:

*Energy Savings, RCx = Penetration of RCx by Building Type x Total Annual Consumption x % End Use Consumption for HVAC x % End Use Savings by Building Type*

The percent of end use consumption for HVAC systems impacted by RCx is based on CEUS, while the end use savings by building type is based on literature reviewed for the 2015 and 2018 Studies.[167,168,169] Savings for offices, colleges, and schools were capped at 5% to reflect feedback from SCE on their experience.[170] The model uses an EUL of 3 years per CPUC Decision 16-08-019. A ratio of kW to kWh of 0.000112 was applied to all three electric utilities based on an analysis of several statewide and third-party programs operating in California during the 2014-2015 portfolio cycle that included RCx related initiatives.

***Cost***

Costs for electricity and natural gas savings are estimated based on an analysis of the same programs reviewed and referenced in the 2017 Study.

## C.12 Industrial/Agriculture – Strategic Energy Management

### *C.12.1 Summary*

SEM in the industrial and agricultural sectors is a 'holistic' approach to managing energy use that continuously improves energy performance based on various initiatives. SEM, per CPUC and California IOU design, is a continuous improvement approach that focuses on changing business practices to enable companies to save money by reducing energy consumption and waste. The industrial sector SEM pilot program currently being administered by California IOUs served as the basis for this forecast. As defined in the California Industrial SEM Design Guide,[171] leading SEM programs are designed to support industrial companies by focusing on several high-level objectives:

- Implementing EE projects and saving energy, primarily from savings in operations and maintenance (O&M).
- Establishing the energy management system (EMS) or business practices that help a facility to manage and continuously improve energy performance.
- Normalizing, quantifying, and reporting facility-wide energy performance.
- Getting peers to talk to one another.

The model inputs for electric and natural gas shown in the table below represent savings associated with SEM operational and behavioral changes. Savings are estimated based on building type consumption (kWh or therms per year) for each market segment and are applied consistently across utilities. Costs for

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[167] 2014 Retro-Commissioning (RCx) Program Extreme Makeover, CenterPoint Energy at http://www.centerpointenergy.com/en-us/Documents/2014%20RCx%20Kickoff%20Slides.pdf

[168] EPA. http://www.epa.gov/statelocalclimate/documents/pdf/table_rules_of_thumb.pdf

[169] DEER ExAnte2013 - RTU-Retro, Rooftop Unit retrocommissioning COM IOU Workpaper

[170] Informal comment received in response to webinar held April 20, 2017.

[171] Version 1.0, February 8, 2017. Prepared by Sergio Dias Consulting LLC

electricity and natural gas are $0.20/kWh and $1.35/therm, and those are also applied consistently by building and fuel type across utilities.

**Table C-14. Industrial/Agriculture SEM - Key Assumptions**

| Sector | Type | EUL Years | Savings | | Cost | | kW/kWh Savings Ratio |
|---|---|---|---|---|---|---|---|
| | | | kWh | therm | kWh | therm | |
| Industrial | SEM | 4.3 | 1.9% - 4.4% | 1.9% - 3.9% | $0.20 | $1.35 | 0.000195 |
| Agriculture | SEM | 4.3 | 3.1% - 3.9% | 3.0 | $0.20 | $1.35 | 0.000195 |

### *C.12.2 Assumptions and Methodology*

***Eligibility and Participation***

Eligibility and participation estimates in the 2019 Study are consistent with the 2017 Study that defined eligibility and participation based on guidance provided by the CPUC regarding the IOUs and as part of the 2017 SEM Pilot Program development effort.[172] Per the design of the CPUC SEM pilot and the market considerations expressed in the IOU business plans, savings in the industrial sector are initially forecast to begin in 2019 for high use market segments, including the petroleum, food, electronics, and chemicals segments, while more widespread implementation for all other industrial segments begins in 2021. Although in theory SEM applies to all customer sizes, in practice applicability of SEM is constrained to large customers. In general, this guidance does not mean that any industrial or agricultural market segment will be excluded from participating in SEM but does restrict the applicability of SEM to larger participants in each market segment. Consequently, an applicability factor for SEM was defined for all industrial and agricultural market sectors and ranged between 39% and 93% for electricity and 48% to 99% for natural gas for the industrial sector, as shown in Table C-14, and between 40% and 65% for both electricity and natural gas for the agricultural sector as shown in Table C-15.

**Table C-15. Industrial SEM Applicability**

| Segment | Fuel | Applicability |
|---|---|---|
| Ind - Petroleum | kWh | 93% |
| Ind - Food | kWh | 77% |
| Ind - Electronics | kWh | 45% |
| Ind - Stone-Glass-Clay | kWh | 85% |
| Ind - Chemicals | kWh | 74% |
| Ind - Plastics | kWh | 75% |
| Ind - Fabricated Metals | kWh | 72% |
| Ind - Primary Metals | kWh | 59% |

[172] Strategic Energy Management -- Comments and Responses on Design and EMV Guides, http://www.energydataweb.com/cpuc/search.aspx

| Segment | Fuel | Applicability |
|---|---|---|
| Ind - Industrial Machinery | kWh | 48% |
| Ind - Transportation Equipment | kWh | 56% |
| Ind - Paper | kWh | 82% |
| Ind - Printing & Publishing | kWh | 61% |
| Ind - Textiles | kWh | 39% |
| Ind - Lumber & Furniture | kWh | 48% |
| Ind - All Other Industrial | kWh | 48% |
| Ind - Petroleum | therms | 99% |
| Ind - Food | therms | 95% |
| Ind - Electronics | therms | 64% |
| Ind - Stone-Glass-Clay | therms | 97% |
| Ind - Chemicals | therms | 98% |
| Ind - Plastics | therms | 81% |
| Ind - Fabricated Metals | therms | 85% |
| Ind - Primary Metals | therms | 94% |
| Ind - Industrial Machinery | therms | 48% |
| Ind - Transportation Equipment | therms | 66% |
| Ind - Paper | therms | 97% |
| Ind - Printing & Publishing | therms | 82% |
| Ind - Textiles | therms | 50% |
| Ind - Lumber & Furniture | therms | 52% |
| Ind - All Other Industrial | therms | 48% |

**Table C-16. Agricultural SEM Applicability**

| Segment | Fuel | Applicability |
|---|---|---|
| Ag - 110 - CEC custom NAICS code | kWh | 65% |
| Ag - 111 - Crop Production | kWh | 65% |
| Ag - 112 - Animal Production and Aquaculture | kWh | 65% |
| Ag - 113 - Forestry and Logging | kWh | 65% |
| Ag - 114 - Fishing, Hunting and Trapping | kWh | 65% |
| Ag - 221 - CEC custom NAICS code - Water Pump | kWh | 40% |
| Ag - 110 - CEC custom NAICS code | therms | 65% |
| Ag - 111 - Crop Production | therms | 65% |
| Ag - 112 - Animal Production and Aquaculture | therms | 65% |
| Ag - 113 - Forestry and Logging | therms | 65% |
| Ag - 114 - Fishing, Hunting and Trapping | therms | 65% |
| Ag - 221 - CEC custom NAICS code - Water Pump | therms | 40% |

The starting saturation for all segments is estimated at 1.5% with a compound annual growth rate (CAGR) of 6.7% for the reference case and 10.0% for the aggressive case. By 2030 this yields a market saturation of 3.5% and 5.2% for the reference and aggressive cases, respectively.

***Savings***

The savings forecast for SEM is an estimate of O&M savings based on a literature review indicating that an average UES for O&M savings of 3.0% of annual sector level consumption is appropriate for the industrial and agricultural sectors. Savings at the segment level will vary, however, because SEM in the industrial and agricultural sectors applies primarily to usage associated machine drive, process heating, and process refrigeration. As such, segment specific UES values were calculated based on how much energy is consumed for these three uses.

the table below shows how usage varies by sector for the industrial segment where, for example, 93% of petroleum segment consumption is accounted for by the end uses impacted by SEM, versus the textile segment where only 39% of energy is consumed by these same end-use categories. On average, these end uses account for 64% on total industrial sector usage. An SEM segment savings adjustment factor was calculated by dividing the SEM applicable segment consumption by the market average consumption, for example for petroleum sector the SEM applicable segment consumption of 93% was divided by the industrial sector average consumption of 64% to yield an SEM segment UES adjustment factor of 1.5 for the petroleum segment. An SEM UES multiplier was then calculated by multiplying the average SEM industrial sector savings of 3.0% by the SEM segment savings adjustment factor. In this example, the average SEM industrial sector savings of 3.0% was multiplied by the UES adjustment factor of 1.5 for the petroleum segment, yielding a multiplier of 4.4%. The table below provides the UES multipliers used to forecast natural gas savings.

**Table C-17. Industrial SEM Electricity UES Multipliers**

| Segment | SEM Target End Uses | | | SEM Applicable Segment Consumption | SEM Segment Savings Adjustment Factor | SEM UES Multiplier |
|---|---|---|---|---|---|---|
| | Machine Drives | Process Heat | Process Refrigeration | | | |
| Petroleum | 88% | 0% | 6% | 93% | 1.5 | 4.4% |
| Stone-Glass-Clay | 61% | 24% | 1% | 85% | 1.3 | 4.0% |
| Paper | 77% | 4% | 2% | 82% | 1.3 | 3.9% |
| Food | 42% | 7% | 29% | 77% | 1.2 | 3.7% |
| Plastics | 51% | 15% | 9% | 75% | 1.2 | 3.6% |
| Chemicals | 61% | 5% | 9% | 74% | 1.2 | 3.5% |
| Fabricated Metals | 49% | 20% | 3% | 72% | 1.1 | 3.4% |
| Printing & Publishing | 52% | 2% | 7% | 61% | 1.0 | 2.9% |
| Primary Metals | 29% | 29% | 1% | 59% | 0.9 | 2.8% |
| Transportation Equipment | 37% | 13% | 6% | 56% | 0.9 | 2.7% |
| All Other Industrial | 33% | 9% | 6% | 48% | 0.8 | 2.3% |
| Industrial Machinery | 33% | 9% | 6% | 48% | 0.8 | 2.3% |
| Lumber & Furniture | 36% | 8% | 4% | 48% | 0.7 | 2.3% |
| Electronics | 21% | 12% | 12% | 45% | 0.7 | 2.2% |
| Textiles | 31% | 5% | 3% | 39% | 0.6 | 1.9% |

*Source: Navigant analysis*

**Table C-18. Industrial SEM Natural Gas UES Multipliers**

| Segment | SEM Target End Uses | | | SEM Segment Savings Adjustment Factor | SEM UES Multiplier |
|---|---|---|---|---|---|
| | Service Hot Water | Process Heat | Other | | |
| Petroleum | 14% | 59% | 26% | 1.3 | 3.861% |
| Stone-Glass-Clay | 1% | 90% | 6% | 1.3 | 3.765% |
| Paper | 25% | 26% | 46% | 1.3 | 3.783% |
| Food | 59% | 28% | 9% | 1.2 | 3.713% |
| Plastics | 46% | 24% | 11% | 1.1 | 3.162% |
| Chemicals | 28% | 28% | 43% | 1.3 | 3.834% |
| Fabricated Metals | 15% | 65% | 6% | 1.1 | 3.330% |
| Printing & Publishing | 13% | 64% | 5% | 1.1 | 3.199% |
| Primary Metals | 5% | 78% | 10% | 1.2 | 3.645% |
| Transportation Equipment | 15% | 30% | 21% | 0.9 | 2.569% |
| All Other Industrial | 16% | 20% | 12% | 0.6 | 1.873% |
| Industrial Machinery | 16% | 20% | 12% | 0.6 | 1.873% |
| Lumber & Furniture | 12% | 28% | 12% | 0.7 | 2.023% |
| Electronics | 42% | 10% | 12% | 0.8 | 2.496% |
| Textiles | 18% | 19% | 13% | 0.6 | 1.947% |

The 2019 Study uses this same process to develop savings multipliers for the agricultural sector, however because NAICS codes associated with the agricultural sector were changed to align with the IEPR definition of the agricultural sector, the same level of data used in the in industrial sector forecast was not available. As such, the average UES for O&M savings of 3.0% of annual sector level consumption was used for most agricultural market segments with adjustments for segments that are primarily large motor loads, such as municipal and irrigation water pumping, as shown in Table C-18.

**Table C-19. Agricultural SEM Electricity and Natural Gas UES Multipliers**

| Segment | Fuel | SEM UES Multiplier |
|---|---|---|
| Ag - 111 - Crop Production | kWh | 3.1% |
| Ag - 112 - Animal Production and Aquaculture | kWh | 3.1% |
| Ag - 113 - Forestry and Logging | kWh | 3.1% |
| Ag - 114 - Fishing, Hunting and Trapping | kWh | 3.1% |
| Ag - 221 - CEC custom NAICS code - Water Pump | kWh | 3.9% |
| Ag - 111 - Crop Production | therms | 3.0% |
| Ag - 112 - Animal Production and Aquaculture | therms | 3.0% |
| Ag - 113 - Forestry and Logging | therms | 3.0% |

| | | |
|---|---|---|
| Ag - 114 - Fishing, Hunting and Trapping | therms | 3.0% |
| Ag - 221 – Municipal and Irrigation Water Pumping | therms | 3.0% |

*Source: Navigant analysis*

The 2019 Study uses the SEM UES multiplier to forecast segment level potential net savings using the following equation:

SEM segment level EE net savings potential =
SEM UES Multiplier x Annual Segment Consumption[173]

The model holds the industrial and agricultural segment UES multiplier constant throughout the forecast horizon.

***Cost***

Costs for electricity and natural gas savings are estimated at \$0.20/kWh and \$1.35/therm and are applied consistently by building and fuel type across utilities. Costs are based on an analysis of third-party industrial sector programs operating in California during the 2014-2015 portfolio. These costs are lower than those for emerging technology and generic custom type measures, reflecting that SEM savings are O&M based and do not include rebate measures for large capital investments.

[173] Electric (GWh) and natural gas (therm) from the 2017 IEPR Forecast

# APPENDIX D. AIMS SECTORS

This appendix provides additional detail and data for the industrial and agriculture sectors. Industrial and Agricultural building types are classified by grouping buildings in NAICS codes. The table below references the building types used in this study with their associated NAICS codes.

| Sector | Subsector (Building Type) | NAICS |
|---|---|---|
| Industrial | Chemicals | 325 |
| | Electronics | 334x, 335 |
| | Fabricated Metals | 332 |
| | Food | 311x, 312 |
| | Industrial Machinery | 333 |
| | Lumber & Furniture | 337, 321, 1133 |
| | Paper | 322x |
| | Petroleum | 324 |
| | Plastics | 326 |
| | Primary Metals | 331 |
| | Printing & Publishing | 323, 511, 516 |
| | Stone-Glass-Clay | 327x |
| | Textiles | 313, 314, 315, 316 |
| | Transportation Equipment | 336 |
| | All Other Industrial | 339 |
| Agriculture | Dairies, fishing, and hunting | 112, 114 |
| | Irrigated Agriculture, vineyards, forestry, and greenhouses | 111, 113 |
| | Water pumping | 221 |

## D.1 Industrial

The following table displays the industrial measure list used in the diffusion model.

| Measure Name | End-Use Category | Description |
|---|---|---|
| HVAC Equipment Upgrade (Electric and Gas) | HVAC | Upgrades to electric and gas HVAC equipment (using better than code energy-efficiency rating [EER] or coefficient of performance [COP]), and heat recovery |
| EE Lighting | Lighting | Lighting controls and early retirement potential to LED fixtures |

| Measure Name | End-Use Category | Description |
|---|---|---|
| Compressed Air | Machine Drive | Air compressor adjustments such as pressure reduction, staging, system controls, and leak identification and repair. VFD controls on air compressors to allow for loading/unloading of the compressed air system, and to replace any inefficient throttling devices |
| Fan VFD | Machine Drive | Variable frequency drive (VFD) controls on fans (not including HVAC fans) to take advantage of partial load conditions |
| Pump Upgrades | Machine Drive | Proper sizing and operation of pumps to increase pump efficiency |
| Energy Efficient Aerator | Machine Drive | Replacing existing inefficient aerators on wastewater systems with higher efficiency aerator technologies |
| Motor VFD | Machine Drive | Installation of higher efficient or premium motors across all industry processes |
| Pump VFD | Machine Drive | VFD controls on pumps to take advantage of partial load conditions |
| Boiler Controls and Optimization | Process Heating | Pressure reduction, leak reduction, steam trap maintenance, and advanced controls on boilers |
| Process Heat | Process Heating | Upgrades and add-ons to gas furnaces and ovens, including infrared (IR), furnace configuration, and advanced controls |
| Heat Recovery | Process Heating | Capturing “waste heat,” produced primarily from gas boilers, and using it in other phases of the industrial process |
| Insulation | Process Heating | Insulation or improved insulation on boiler equipment, storage tanks, and other process piping |
| Chiller | Process Refrigeration | Chiller upgrades including advanced controls, higher efficiency equipment, and overall system efficiency improvements |
| Refrigeration | Process Refrigeration | Advanced controls on refrigeration systems including floating head controls, evaporator fan controls, and condenser controls |

*Source: Navigant 2016*

## D.2 Agriculture

The following table describes the list of agricultural measures used in the diffusion model.

| Measure Name | End-Use Category | Description |
|---|---|---|
| HVAC Ventilation (Fan Ventilation Improvement) | HVAC | Upgrade to more efficient fans, temperature and humidity controls, VFDs (includes post-harvest process fan aeration improvements) |
| HVAC Chiller Water Cooled | HVAC | Chiller upgrades including advanced controls, higher efficiency equipment, and overall system efficiency improvements |
| Ag Irrigation Pump | Machine Drive | Irrigation specific pump improvement, maintenance, and replacement designed to increase pump efficiency |
| Ag Pump VFD | Machine Drive | VFD for irrigation specific pumps (well, irrigation, booster, etc.) |
| Low Pressure Irrigation | Machine Drive | Conversion from high to low pressure irrigation (sprinkler to drip, low pressure nozzles, etc.) |
| Ag Pump Retrofit – Non-Irrigation | Machine Drive | Pump retrofits geared to all other pumps besides irrigation specific pumps |
| Ag Pump VFD - Dairy | Machine Drive | VFD for dairy specific pumps (vacuum, transfer, etc.) |
| Process Wastewater Aerator | Machine Drive | Replacing existing inefficient aerators on wastewater systems with higher efficiency aerator technologies |
| Exterior Lighting Upgrades | Lighting*[174] | Includes typical C&I exterior LED lighting measures as well as exterior security lights |
| Horticulture Interior LED Grow Lighting | Lighting | Indoor LED lamps and fixtures used for growing a variety of plants |
| Interior Lighting Upgrades - LED | Lighting | Includes typical C&I LED lighting measures and applications as well as agriculture-rated LEDs for animal health and animal-specific purposes |
| Interior Lighting Upgrades – Non-LED | Lighting | Includes typical C&I non-LED lighting measures and applications |
| Lighting Controls | Lighting | Occupancy sensors, photocells/timers, etc. |
| Greenhouse Process Heating Optimization | Process Heating | Heating optimization and equipment improvements for greenhouses (unit to bench heating conversion, boiler improvement measures, dynamic temperature controls, etc.) |
| Greenhouse Shell Improvements | Process Heating | Heating optimization improvements for greenhouses centered around shell improvements (thermal and shade curtains, insulation upgrades, IRAC film, etc.) |
| Post-Harvest Process Improvements | Process Heating | Gas improvements to post-harvesting such as more efficient heated grain drying, heat recovery, process controls |

[174] All lighting is considered retrofit to allow for early retirement retrofits with the year 2019 for LED become baseline.

| Measure Name | End-Use Category | Description |
|---|---|---|
| Pipe Insulation Hot Application | Process Heating | Insulation or improved insulation on boiler equipment, storage tanks, and other process piping |
| Process Refrigeration Retrofit - Dairy | Process Refrigeration | Refrigeration improvements to process milk cooling on dairies (plate coolers, scroll compressors) |
| Refrigeration Retrofit (Refrigeration System Optimization) | Process Refrigeration | Includes typical C&I refrigeration improvements to cold storage areas (floating head pressure controls, evaporator fan controls, evaporator fan ECMs, etc.) |

*Source: Navigant 2016*

# APPENDIX E. CODES & STANDARDS

**Table E-1. C&S Modeled**

| Regulation | Code or Standard Name | Compliance Rate[175] | Effective Date | Policy View |
|---|---|---|---|---|
| 2005 T-20 | Commercial Refrigeration Equipment, Solid Door | 70% | 1/1/2006 | On the books |
| 2005 T-20 | Commercial Refrigeration Equipment, Transparent Door | 70% | 1/1/2007 | On the books |
| 2005 T-20 | Commercial Ice Maker Equipment | 70% | 1/1/2008 | On the books |
| 2005 T-20 | Walk-In Refrigerators / Freezers | 91% | 1/1/2006 | On the books |
| 2005 T-20 | Refrigerated Beverage Vending Machines | 37% | 1/1/2006 | On the books |
| 2005 T-20 | Large Packaged Commercial Air-Conditioners, Tier 1 | 70% | 10/1/2006 | On the books |
| 2005 T-20 | Large Packaged Commercial Air-Conditioners, Tier 2 | 70% | 1/1/2010 | On the books |
| 2005 T-20 | Residential Pool Pumps, High Eff Motor, Tier 1 | 100% | 1/1/2006 | On the books |
| 2005 T-20 | Portable Electric Spas | 70% | 1/1/2006 | On the books |
| 2005 T-20 | General Service Incandescent Lamps, Tier 1 | 69% | 1/1/2006 | On the books |
| 2005 T-20 | Pulse Start Metal Halide HID Luminaires, Tier 1(Vertical Lamps) | 100% | 1/1/2006 | On the books |
| 2005 T-20 | Pulse Start Metal Halide HID Luminaires, Tier 2(All other MH | 100% | 1/1/2008 | On the books |
| 2005 T-20 | Modular Furniture Task Lighting Fixtures | 70% | 1/1/2008 | On the books |
| 2005 T-20 | Hot Food Holding Cabinets | 70% | 1/1/2006 | On the books |
| 2005 T-20 | External Power Supplies, Tier 1 | 100% | 1/1/2007 | On the books |
| 2005 T-20 | External Power Supplies, Tier 2 | 99% | 7/1/2008 | On the books |
| 2005 T-20 | Consumer Electronics - Audio Players | 100% | 1/1/2007 | On the books |
| 2005 T-20 | Consumer Electronics - TVs | 96% | 1/1/2006 | On the books |
| 2005 T-20 | Consumer Electronics - DVDs | 31% | 1/1/2006 | On the books |
| 2005 T-20 | Water Dispensers | 70% | 1/1/2006 | On the books |
| 2005 T-20 | Unit Heaters and Duct Furnaces | 100% | 1/1/2006 | On the books |
| 2005 T-20 | Commercial Dishwasher Pre-Rinse Spray Valves | 100% | 1/1/2006 | On the books |
| 2006 T-20 | Residential Pool Pumps, 2-speed Motors, Tier 2 | 86% | 1/1/2008 | On the books |
| 2006 T-20 | General Service Incandescent Lamps, Tier 2 #1 | 87% | 1/1/2008 | On the books |
| 2006 T-20 | General Service Incandescent Lamps, Tier 2 #2 | 87% | 1/1/2008 | On the books |

[175] Compliance rates are specific to 2016 for electric energy savings. Full details are available in the model.

| | | | | |
|---|---|---|---|---|
| 2006 T-20 | General Service Incandescent Lamps, Tier 2 #3 | 89% | 1/1/2008 | On the books |
| 2006 T-20 | BR, ER and R20 Incandescent Reflector Lamps: Residential | 82% | 1/8/2008 | On the books |
| 2006 T-20 | BR, ER and R20 Incandescent Reflector Lamps: Commercial | 82% | 1/8/2008 | On the books |
| 2008 T-20 | Metal Halide Fixtures | 95% | 1/1/2010 | On the books |
| 2008 T-20 | Portable Lighting Fixtures | 93% | 1/1/2010 | On the books |
| 2008 T-20 | General Purpose Lighting -- 100 watt | 88% | 1/1/2011 | On the books |
| 2008 T-20 | General Purpose Lighting -- 75 watt | 40% | 1/1/2012 | On the books |
| 2008 T-20 | General Purpose Lighting -- 60 and 40 watt | 85% | 1/1/2013 | On the books |
| 2009 T-20 | Televisions - Tier 1 | 98% | 1/1/2011 | On the books |
| 2009 T-20 | Televisions - Tier 2 | 99% | 1/1/2013 | On the books |
| 2011 T-20 | Small Battery Chargers – Tier 1 (consumer with no USB charger or USB charger <20 watt-hours) | 90% | 2/1/2013 | On the books |
| 2011 T-20 | Small Battery Chargers – Tier 2 (consumer with USB charger ≥20 watt-hours) | 88% | 1/1/2014 | On the books |
| 2011 T-20 | Small Battery Chargers – Tier 3 (non-consumer) | 85% | 1/1/2017 | On the books |
| 2011 T-20 | Large Battery Chargers (≥2kW rated input) | 78% | 1/1/2014 | On the books |
| Unevaluated T-20 | Residential Faucets & Aerators - Lavatory w/ Natural Gas Water Heating - Tier 1 | 88% | 9/1/2015 | On the books |
| Unevaluated T-20 | Residential Faucets & Aerators - Lavatory w/ Electric Water Heating - Tier 1 | 88% | 9/1/2015 | On the books |
| Unevaluated T-20 | Residential Faucets & Aerators - Lavatory w/ Natural Gas Water Heating - Tier 2 | 88% | 7/1/2016 | On the books |
| Unevaluated T-20 | Residential Faucets & Aerators - Lavatory w/ Electric Water Heating - Tier 2 | 88% | 7/1/2016 | On the books |
| Unevaluated T-20 | Residential Faucets & Aerators - Kitchen w/ Natural Gas Water Heating | 88% | 1/1/2016 | On the books |
| Unevaluated T-20 | Residential Faucets & Aerators - Kitchen w/ Electric Water Heating | 88% | 1/1/2016 | On the books |
| Unevaluated T-20 | Public Lavatory Faucets | 88% | 1/1/2016 | On the books |
| Unevaluated T-20 | Showerheads - w/ Natural Gas Water Heaters - Tier 1 | 88% | 7/1/2016 | On the books |
| Unevaluated T-20 | Showerheads - w/ Electric Water Heaters - Tier 1 | 88% | 7/1/2016 | On the books |
| Unevaluated T-20 | Showerheads - w/ Natural Gas Water Heaters - Tier 2 | 88% | 7/1/2018 | On the books |
| Unevaluated T-20 | Showerheads - w/ Electric Water Heaters - Tier 2 | 88% | 7/1/2018 | On the books |
| Unevaluated T-20 | Commercial Toilets | 88% | 1/1/2016 | On the books |
| Unevaluated T-20 | Residential Toilets | 88% | 1/1/2016 | On the books |

| | | | | |
|---|---|---|---|---|
| Unevaluated T-20 | Urinals | 88% | 1/1/2016 | On the books |
| Unevaluated T-20 | Dimming Ballasts | 88% | 7/1/2016 | On the books |
| Unevaluated T-20 | GSLs - Original Scope - Tier 2 | 88% | 1/1/2018 | On the books |
| Unevaluated T-20 | Small Diameter Directional Lamps | 88% | 1/1/2018 | On the books |
| Unevaluated T-20 | LED Lamps - Tier 1 | 88% | 1/1/2018 | On the books |
| Unevaluated T-20 | LED Lamps - Tier 2 | 88% | 7/1/2019 | On the books |
| Unevaluated T-20 | Computers - Workstations | 88% | 1/1/2018 | On the books |
| Unevaluated T-20 | Computers - Small Scale Servers | 88% | 1/1/2018 | On the books |
| Unevaluated T-20 | Computers - Notebooks | 88% | 1/1/2019 | On the books |
| Unevaluated T-20 | Computers - Desktops - Tier 1 | 88% | 1/1/2019 | On the books |
| Unevaluated T-20 | Computers - Desktops - Tier 2 | 88% | 7/1/2021 | On the books |
| Unevaluated T-20 | Displays - Monitors | 88% | 7/1/2019 | On the books |
| Unevaluated T-20 | Air Filter Labeling | 88% | 4/1/2019 | On the books |
| Unevaluated T-20 | Portable Electric Spas - Rigid | 88% | 6/1/2019 | On the books |
| Unevaluated T-20 | Portable Electric Spas - Inflatable | 88% | 6/1/2019 | On the books |
| Unevaluated T-20 | Portable ACs | 88% | 1/1/2021 | On the books |
| Future Title 20 | Fans & Blowers | 88% | 1/1/2022 | Possible |
| Future Title 20 | GSFLs (T12 Loophole) | 88% | 1/1/2020 | Possible |
| Future Title 20 | Compressors | 88% | 1/1/2020 | Possible |
| Future Title 20 | Hearth Products | 88% | 1/1/2021 | Possible |
| Future Title 20 | Irrigation Controllers | 88% | 1/1/2022 | Possible |
| Future Title 20 | Residential fans (exhaust, whole house, etc.) | 85% | 1/1/2024 | Possible |
| Future Title 20 | Small Network Equipment | 85% | 1/1/2025 | Possible |
| Future Title 20 | Single-Speed Residential Filtration | 85% | 1/1/2021 | Expected |
| Future Title 20 | Commercial Clothes Dryers | 85% | 1/1/2022 | Expected |

| | | | | |
|---|---|---|---|---|
| Future Title 20 | Commercial Imaging equipment | 85% | 1/1/2027 | Possible |
| Future Title 20 | Residential Imaging equipment | 85% | 1/1/2027 | Possible |
| Federal | Electric Motors 1-200HP | 91% | 12/1/2010 | On the books |
| Federal | Refrigerated Beverage Vending Machines | 37% | 8/31/2011 | On the books |
| Federal | Commercial Refrigeration | 70% | 1/1/2012 | On the books |
| Federal | Residential Electric & Gas Ranges | 100% | 4/9/2012 | On the books |
| Federal | General Service Fluorescent Lamps #1 | 95% | 7/14/2012 | On the books |
| Federal | Incandescent Reflector Lamps | 65% | 7/14/2012 | On the books |
| Federal | Commercial Clothes Washers #1 | 94% | 1/8/2013 | On the books |
| Federal | Residential Pool Heaters | 95% | 4/16/2013 | On the books |
| Federal | Residential Direct Heating Equipment | 95% | 4/16/2013 | On the books |
| Federal | Residential Refrigerators & Freezers | 95% | 9/15/2014 | On the books |
| Federal | Residential Room AC | 91% | 6/1/2014 | On the books |
| Federal | Fluorescent Ballasts | 80% | 11/14/2014 | On the books |
| Federal | Small Commercial Package Air-Conditioners ≥65 and <135 kBtu/h | 100% | 6/1/2013 | On the books |
| Federal | Large and Very Large Commercial Package Air-Conditioners ≥135 kBtu/h | 100% | 6/1/2014 | On the books |
| Federal | Computer Room ACs >=65,000 Btu/h and < 760,000 Btu/h | 100% | 10/29/2013 | On the books |
| Federal | Residential Dishwashers | 99% | 5/30/2013 | On the books |
| Federal | Residential Clothes Dryers | 99% | 1/15/2015 | On the books |
| Federal | Residential Gas-fired water heater | 98% | 4/16/2015 | On the books |
| Federal | Residential Electric storage water heater | 88% | 4/16/2015 | On the books |
| Federal | Residential Gas-fired instantaneous water heater | 87% | 4/16/2015 | On the books |
| Federal | Residential Oil-fired storage water heater | 85% | 4/16/2015 | On the books |
| Federal | Small Electric Motors | 35% | 3/9/2015 | On the books |
| Federal | Residential Clothes Washers (Front Loading) | 100% | 3/7/2015 | On the books |
| Federal | Residential Clothes Washers (Top Loading) Tier I | 100% | 3/7/2015 | On the books |
| Federal | Residential Central AC, Heat Pumps and Furnaces | 99% | 1/1/2015 | On the books |
| Federal | ASHRAE Products (Commercial boilers) | 95% | 3/2/2012 | On the books |
| Federal | Single package vertical AC and HP - >65,000 Btu/hr and <240,000 Btu/hr | 95% | 10/9/2015 | On the books |
| Federal | Distribution transformers | 95% | 1/1/2016 | On the books |
| Federal | External Power Supplies | 95% | 2/10/2016 | On the books |
| Federal | Electric Motors | 95% | 6/1/2016 | On the books |
| Federal | Microwave ovens | 95% | 6/17/2016 | On the books |
| Federal | Commercial CAC and HP - <65,000 Btu/hr | 95% | 1/1/2017 | On the books |
| Federal | Metal Halide Lamp Fixtures | 95% | 2/10/2017 | On the books |

| | | | | |
|---|---|---|---|---|
| Federal | Commercial Refrigeration Equipment | 95% | 3/27/2017 | On the books |
| Federal | Walk-in coolers and freezers | 95% | 6/5/2017 | On the books |
| Federal | Commercial Clothes Washers | 95% | 1/1/2018 | On the books |
| Federal | GSFLs | 95% | 1/26/2018 | On the books |
| Federal | Residential Clothes Washers - Top-loading | 95% | 1/1/2018 | On the books |
| Federal | Commercial CAC and HP - 65,000 Btu/hr to 760,000 Btu/hr - Tier 1 | 95% | 1/1/2018 | On the books |
| Federal | Commercial CAC and HP - 65,000 Btu/hr to 760,000 Btu/hr - Tier 2 | 95% | 1/1/2023 | On the books |
| Federal | Commercial Ice Makers | 95% | 1/28/2018 | On the books |
| Federal | Pre-rinse Spray Valves | 95% | 1/28/2019 | On the books |
| Federal | Refrigerated beverage vending machines #2 | 95% | 1/8/2019 | On the books |
| Federal | Dehumidifiers | 95% | 6/13/2019 | On the books |
| Federal | Furnace fans | 95% | 7/3/2019 | On the books |
| Federal | Single package vertical AC and HP - <65,000 Btu/hr | 95% | 9/23/2019 | On the books |
| Federal | Wine chillers | 95% | 10/28/2019 | On the books |
| Federal | Ceiling Fans | 95% | 1/21/2020 | On the books |
| Federal | Ceiling Fan Light Kits | 95% | 1/21/2020 | On the books |
| Federal | Commercial and Industrial Pumps | 95% | 1/27/2020 | On the books |
| Federal | Residential Boilers - Gas-fired Hot Water and Electric Hot Water | 95% | 1/15/2021 | On the books |
| Federal | Residential Boilers - Gas-fired Steam and Electric Steam | 95% | 1/15/2021 | On the books |
| Federal | Pool Pumps | 95% | 7/19/2021 | On the books |
| Federal | Dedicated-Purpose Pool Pumps | 95% | 7/19/2021 | On the books |
| Federal | Commercial Furnaces | 95% | 1/1/2023 | On the books |
| Federal | Residential Central AC, HP, and Furnaces | 95% | 1/1/2023 | On the books |
| Federal | Water-Source Heat Pumps | 95% | 1/1/2026 | On the books |
| Future Federal | GSLs - Expanded Scope[176] | 76% | 1/1/2020 | Possible |
| Future Federal | Commercial Boilers | 95% | 1/1/2023 | Possible |
| Future Federal | Residential Electric & Gas Ranges | 95% | 1/1/2023 | Possible |
| Future Federal | Circulator Pumps | 95% | 1/1/2023 | Possible |
| Future Federal | Fluorescent Ballasts | 95% | 11/14/2025 | Possible |

[176] Although the IOUs provided this as a claimed standard starting in the year 2020, the stated intent by the federal government to roll back this standard as well as the uncertainty in possible legal challenges makes the savings uncertain. For this reason, the GSL - Expanded Scope standard is listed as "Possible" and therefore does not contribute to C&S savings reported in this study. However, the model can produce a forecast of savings from "Possible" C&S for use by the California Energy Commission in its analysis of Additional Achievable Energy Efficiency.

| | | | | |
|---|---|---|---|---|
| Future Federal | Residential Clothes Dryers | 95% | 1/15/2025 | Possible |
| Future Federal | Residential Room ACs | 95% | 6/1/2025 | Possible |
| Future Federal | Residential Furnaces | 95% | 3/1/2026 | Possible |
| Future Federal | Residential central AC (not heat pumps) | 85% | 1/1/2031 | Possible |
| Future Federal | Ranges and ovens (gas) | 85% | 1/1/2030 | Possible |
| Future Federal | Commercial package AC and heating equipment | 85% | 1/1/2031 | Possible |
| Future Federal | Commercial water heaters | 85% | 1/1/2029 | Possible |
| Future Federal | High efficiency gas storage water heaters | 85% | 1/1/2025 | Possible |
| Future Federal | High efficiency gas tankless water heaters | 85% | 1/1/2025 | Possible |
| Future Federal | Residential heat pump water heaters | 85% | 1/1/2025 | Possible |
| Future Federal | Residential Refrigerators and Freezers | 85% | 1/1/2026 | Possible |
| Future Federal | Small Motors | 85% | 1/1/2025 | Possible |
| Future Federal | Computer Room Air Conditioners (CRAC) | 85% | 1/1/2025 | Possible |
| Future Federal | Ranges and ovens (electric) | 85% | 1/1/2030 | Possible |
| Future Federal | Packaged Terminal AC (PTAC) and HP (PTHP) | 85% | 1/1/2028 | Possible |
| 2005 T-24 | Time dependent valuation, Residential | 0% | 1/1/2006 | On the books |
| 2005 T-24 | Time dependent valuation, Nonresidential | 0% | 1/1/2006 | On the books |
| 2005 T-24 | Res. Hardwired lighting | 113% | 1/1/2006 | On the books |
| 2005 T-24 | Duct improvement | 59% | 1/1/2006 | On the books |
| 2005 T-24 | Window replacement | 80% | 1/1/2006 | On the books |
| 2005 T-24 | Lighting controls under skylights | 8% | 1/1/2006 | On the books |
| 2005 T-24 | Ducts in existing commercial buildings | 75% | 1/1/2006 | On the books |
| 2005 T-24 | Cool roofs | 75% | 1/1/2006 | On the books |
| 2005 T-24 | Relocatable classrooms | 100% | 1/1/2006 | On the books |
| 2005 T-24 | Bi-level lighting control credits | 79% | 1/1/2006 | On the books |
| 2005 T-24 | Duct testing/sealing in new commercial buildings | 82% | 1/1/2006 | On the books |
| 2005 T-24 | Cooling tower applications | 88% | 1/1/2006 | On the books |
| 2005 T-24 | Multifamily Water Heating | 78% | 1/1/2006 | On the books |
| 2005 T-24 | Composite for Remainder - Res | 120% | 1/1/2006 | On the books |
| 2005 T-24 | Composite for Remainder - Non-Res | 85% | 1/1/2006 | On the books |

| | | | | |
|---|---|---|---|---|
| 2005 T-24 | Whole Building - Res New Construction (Electric) | 120% | 1/1/2006 | On the books |
| 2005 T-24 | Whole Building - Non-Res New Construction (Electric) | 0% | 1/1/2006 | On the books |
| 2005 T-24 | Whole Building - Res New Construction (Gas) | 235% | 1/1/2006 | On the books |
| 2005 T-24 | Whole Building - Non-Res New Construction (Gas) | 0% | 1/1/2006 | On the books |
| 2008 T-24 | Envelope insulation | 123% | 10/1/2010 | On the books |
| 2008 T-24 | Overall Envelope Tradeoff | 397% | 10/1/2010 | On the books |
| 2008 T-24 | Skylighting | 397% | 10/1/2010 | On the books |
| 2008 T-24 | Sidelighting | 397% | 10/1/2010 | On the books |
| 2008 T-24 | Tailored Indoor lighting | 573% | 10/1/2010 | On the books |
| 2008 T-24 | TDV Lighting Controls | 0% | 10/1/2010 | On the books |
| 2008 T-24 | DR Indoor Lighting | 397% | 10/1/2010 | On the books |
| 2008 T-24 | Outdoor Lighting | 83% | 10/1/2010 | On the books |
| 2008 T-24 | Outdoor Signs | 83% | 10/1/2010 | On the books |
| 2008 T-24 | Refrigerated warehouses | 83% | 10/1/2010 | On the books |
| 2008 T-24 | DDC to Zone | 397% | 10/1/2010 | On the books |
| 2008 T-24 | Residential Swimming pool | 83% | 7/1/2010 | On the books |
| 2008 T-24 | Site Built Fenestration | 83% | 10/1/2010 | On the books |
| 2008 T-24 | Residential Fenestration | 83% | 7/1/2010 | On the books |
| 2008 T-24 | Cool Roof Expansion | 153% | 10/1/2010 | On the books |
| 2008 T-24 | MF Water heating control | 0% | 9/1/2010 | On the books |
| 2008 T-24 | CfR IL Complete Building Method | 571% | 9/1/2010 | On the books |
| 2008 T-24 | CfR IL Area Category Method | 569% | 9/1/2010 | On the books |
| 2008 T-24 | CfR IL Egress Control | 397% | 9/1/2010 | On the books |
| 2008 T-24 | CfR HVAC Efficiency | 397% | 9/1/2010 | On the books |
| 2008 T-24 | CfR Res Cool Roofs | 83% | 9/1/2010 | On the books |
| 2008 T-24 | CfR Res Central Fan WL | 83% | 9/1/2010 | On the books |
| 2013 T-24 | NRA-Lighting-Alterations-New Measures | 91% | 7/1/2014 | On the books |
| 2013 T-24 | NRA-Lighting-Alterations-Existing Measures | 91% | 7/1/2014 | On the books |
| 2013 T-24 | NRA-Lighting-Egress Lighting Control | 91% | 7/1/2014 | On the books |
| 2013 T-24 | NRA-Lighting-MF Building Corridors | 91% | 7/1/2014 | On the books |
| 2013 T-24 | NRA-Lighting-Hotel Corridors | 91% | 7/1/2014 | On the books |
| 2013 T-24 | NRA-Lighting-Warehouses and Libraries | 91% | 7/1/2014 | On the books |
| 2013 T-24 | NRA-Envelope-Cool Roofs | 83% | 7/1/2014 | On the books |
| 2013 T-24 | NRA-HVAC-Equipment Efficiency | 83% | 7/1/2014 | On the books |
| 2013 T-24 | NRA-Process-Air Compressors | 83% | 7/1/2014 | On the books |
| 2013 T-24 | NRNC-Lighting-Egress Lighting Control | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-Lighting-MF Building Corridors | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-Lighting-Hotel Corridors | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-Lighting-Warehouses and Libraries | 83% | 4/1/2015 | On the books |

| | | | | |
|---|---|---|---|---|
| 2013 T-24 | NRNC-Lighting-Parking Garage | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-Lighting-Controllable Lighting | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-Lighting-DR Lighting Controls | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-Lighting-Outdoor Lighting & Controls | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-Lighting-Office Plug Load Control | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-HVAC-Garage Exhaust | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-HVAC-Laboratory Exhaust | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-HVAC-Small ECM Motor | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-HVAC-Water & Space Heating ACM | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-HVAC-Cooling Towers Water | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-HVAC-Occupant Controlled Smart Thermostats | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-HVAC-Low-Temp Radiant Cooling | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-HVAC-Evap Cooling Credit | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-HVAC-Outside Air | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-HVAC-Acceptance Requirements | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-Refrigeration-Warehouse | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-Refrigeration-Supermarket | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-Process-Process Boilers | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-Process-Air Compressors | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-Process-Data Centers | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-DHW - Hotel DHW Control and Solar | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-DHW-Solar Water Heating | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-Solar-Solar Ready | 83% | 4/1/2015 | On the books |
| 2013 T-24 | NRNC-Whole Building | 93% | 4/1/2015 | On the books |
| 2013 T-24 | RNC-Lighting | 0% | 1/1/2015 | On the books |
| 2013 T-24 | RNC-DHW - MF DHW Control and Solar | 83% | 4/1/2015 | On the books |
| 2013 T-24 | RNC-DHW - High Efficiency Water Heater Ready | 83% | 1/1/2015 | On the books |
| 2013 T-24 | RNC-DHW - Solar for Electrically Heated Homes | 83% | 1/1/2015 | On the books |
| 2013 T-24 | RNC-Solar - Solar Ready & Oriented Homes | 83% | 1/1/2015 | On the books |
| 2013 T-24 | RNC-SF Whole Building | 67% | 1/1/2015 | On the books |
| 2013 T-24 | RNC-MF Whole Building | 83% | 4/1/2015 | On the books |
| 2013 T-24 | RA-SF Whole Building | 67% | 7/1/2014 | On the books |
| 2013 T-24 | RA-MF Whole Building | 83% | 7/1/2014 | On the books |
| 2016 T-24 | NRA-Lighting-Alterations | 85% | 2/1/2017 | On the books |
| 2016 T-24 | NRA-Lighting-Outdoor Lighting Controls | 85% | 2/1/2017 | On the books |
| 2016 T-24 | NRA-Lighting-ASHARE Measure-Elevator Lighting & Ventilation | 85% | 2/1/2017 | On the books |

| | | | | |
|---|---|---|---|---|
| 2016 T-24 | NRA-Envelope-Opaque Wall (Roof Alterations) | 85% | 2/1/2017 | On the books |
| 2016 T-24 | NRA-HVAC-ASHARE Measure-DDC | 85% | 2/1/2017 | On the books |
| 2016 T-24 | NRA-HVAC-ASHRAE Equipment Efficiency | 85% | 2/1/2017 | On the books |
| 2016 T-24 | NRA-Process-ASHARE Measure-Escalator Speed Control | 85% | 2/1/2017 | On the books |
| 2016 T-24 | NRNC-Whole Building | 85% | 11/1/2017 | On the books |
| 2016 T-24 | RNC-Single Family Whole Building | 85% | 7/1/2017 | On the books |
| 2016 T-24 | RNC-Multifamily Whole Building | 85% | 7/1/2017 | On the books |
| 2016 T-24 | RA-Single Family Whole Building | 85% | 4/1/2017 | On the books |
| 2016 T-24 | RA-Multifamily Whole Building | 85% | 4/1/2017 | On the books |
| 2019 T-24 | NRA-Indoor Lighting-Alterations (Control) | 85% | 3/1/2020 | On the books |
| 2019 T-24 | NRA-Indoor Lighting-Alterations (LPD) | 85% | 3/1/2020 | On the books |
| 2019 T-24 | NRA-Indoor Lighting-New LPD | 85% | 3/1/2020 | On the books |
| 2019 T-24 | NRA-Indoor Lighting-New Controls | 85% | 3/1/2020 | On the books |
| 2019 T-24 | NRA- Outdoor Lighting-LPA (General Hardscape) | 85% | 3/1/2020 | On the books |
| 2019 T-24 | NRA- Outdoor Lighting-LPA (Specific Applications) | 85% | 3/1/2020 | On the books |
| 2019 T-24 | NRA-Outdoor Lighting-Controls | 85% | 3/1/2020 | On the books |
| 2019 T-24 | NRA-MECH-ASHRAE 90.1 | 85% | 3/1/2020 | On the books |
| 2019 T-24 | NRA-MECH-Cooling Towers | 85% | 3/1/2020 | On the books |
| 2019 T-24 | NRA-MECH-HE Fume Hoods in Lab Spaces | 85% | 3/1/2020 | On the books |
| 2019 T-24 | NRA-MECH-Variable Exhaust Flow Control | 85% | 3/1/2020 | On the books |
| 2019 T-24 | NRNC-Indoor Lighting-LPD | 85% | 10/1/2020 | On the books |
| 2019 T-24 | NRNC-Indoor Lighting-Controls | 85% | 10/1/2020 | On the books |
| 2019 T-24 | NRNC- Outdoor Lighting-LPA (General Hardscape) | 85% | 10/1/2020 | On the books |
| 2019 T-24 | NRNC- Outdoor Lighting-LPA (Specific Applications) | 85% | 10/1/2020 | On the books |
| 2019 T-24 | NRNC-Outdoor Lighting-Controls | 85% | 10/1/2020 | On the books |
| 2019 T-24 | NRNC-Envelope-Dock Seals | 85% | 10/1/2020 | On the books |
| 2019 T-24 | NRNC-MECH-Adiabatic Condensers for Refrigeration | 85% | 10/1/2020 | On the books |
| 2019 T-24 | NRNC-MECH-ASHRAE 90.1 | 85% | 10/1/2020 | On the books |
| 2019 T-24 | NRNC-MECH-Cooling Towers | 85% | 10/1/2020 | On the books |
| 2019 T-24 | NRNC-MECH-Economizer FDD | 85% | 10/1/2020 | On the books |
| 2019 T-24 | NRNC-MECH-HE Fume Hoods in Lab Spaces | 85% | 10/1/2020 | On the books |
| 2019 T-24 | NRNC-MECH-Variable Exhaust Flow Control | 85% | 10/1/2020 | On the books |
| 2019 T-24 | NRNC-MECH-Ventilation & IAQ | 85% | 10/1/2020 | On the books |
| 2019 T-24 | RNC(SF)-Envelope-High Performance Attics | 85% | 7/1/2020 | On the books |

| | | | | |
|---|---|---|---|---|
| 2019 T-24 | RNC(SF)-Envelope-High Performance Walls | 85% | 7/1/2020 | On the books |
| 2019 T-24 | RNC(SF)-Envelope-QII | 85% | 7/1/2020 | On the books |
| 2019 T-24 | RNC(SF)-Envelope-Windows and Doors | 85% | 7/1/2020 | On the books |
| 2019 T-24 | RNC(SF)-MECH-Quality HVAC | 85% | 7/1/2020 | On the books |
| 2019 T-24 | RNC(MF)-Envelope-High Performance Attics | 85% | 9/1/2020 | On the books |
| 2019 T-24 | RNC(MF)-Envelope-QII | 85% | 9/1/2020 | On the books |
| 2019 T-24 | RNC(MF)-Envelope-Windows and Doors | 85% | 9/1/2020 | On the books |
| 2019 T-24 | RNC(MF)-MECH-Quality HVAC | 85% | 9/1/2020 | On the books |
| 2019 T-24 | RA(SF)-Envelope-High Performance Walls | 85% | 4/1/2020 | On the books |
| 2019 T-24 | RA(SF)-Envelope-QII | 85% | 4/1/2020 | On the books |
| 2019 T-24 | RA(SF)-Envelope-Windows and Doors | 85% | 4/1/2020 | On the books |
| 2019 T-24 | RA(SF)-MECH-Quality HVAC | 85% | 4/1/2020 | On the books |
| 2019 T-24 | RA(MF)-Envelope-QII | 85% | 4/1/2020 | On the books |
| 2019 T-24 | RA(MF)-Envelope-Windows and Doors | 85% | 4/1/2020 | On the books |
| 2019 T-24 | RA(MF)-MECH-Quality HVAC | 85% | 4/1/2020 | On the books |
| 2022 T-24 | NRA | 80% | 1/31/2023 | Expected |
| 2022 T-24 | NRNC-Whole Building | 80% | 10/31/2023 | Expected |
| 2025 T-24 | NRA | 80% | 1/30/2026 | Possible |
| 2025 T-24 | NRNC-Whole Building | 80% | 10/30/2026 | Possible |
| 2028 T-24 | NRA | 80% | 1/29/2029 | Possible |
| 2028 T-24 | NRNC-Whole Building | 80% | 10/29/2029 | Possible |

Table E-2 specifies all standards that are assumed to be superseded by other standards.

**Table E-2. C&S Superseded Codes and Standards**

| Superseded Code or Standard | Superseding Code or Standard | Source |
|---|---|---|
| 2005 T-20: Walk-in Refrigerators/Freezers | Fed Appliance: Walk-in coolers and freezers | Navigant Assumption |
| 2005 T-20: Commercial Dishwasher Pre-Rinse Spray Valves | Fed Appliance: Pre-Rinse Spray Valves | Navigant Assumption |
| 2005 T-20: Consumer Electronics - TVs | 2009 T-20: Televisions - Tier 1 | ISSM |
| 2005 T-20: Commercial Refrigeration Equipment, Solid Door | Fed Appliance: Commercial Refrigeration | ISSM |
| 2005 T-20: Commercial Refrigeration Equipment, | Fed Appliance: Commercial Refrigeration | ISSM |
| 2005 T-20: Commercial Ice Maker Equipment | Fed Appliance: Commercial Refrigeration | ISSM |
| 2005 T-20: Refrigerated Beverage Vending Machines | Fed Appliance: Refrigerated Beverage Vending Machines | ISSM |
| 2006 T-20: Residential Pool Pumps, 2-speed Motors, Tier 2 | Fed Appliance: Pool Pumps | Navigant Assumption |
| 2006 T-20: BR, ER and R20 Incandescent Reflector Lamps: Residential | Fed Appliance: Incandescent Reflector Lamps | ISSM |
| 2006 T-20: BR, ER and R20 Incandescent Reflector Lamps: Commercial | Fed Appliance: Incandescent Reflector Lamps | ISSM |
| 2006 T-20: General Service Incandescent Lamps, Tier 2 #1 | 2008 T-20: General Purpose Lighting -- 100 watt | ISSM |
| 2006 T-20: General Service Incandescent Lamps, Tier 2 #2 | 2008 T-20: General Purpose Lighting -- 75 watt | ISSM |
| 2006 T-20: General Service Incandescent Lamps, Tier 2 #3 | 2008 T-20: General Purpose Lighting -- 60 and 40 watt | ISSM |
| 2006 T-20: General Service Incandescent Lamps, Tier 2 #1 | EISA | ISSM |
| 2006 T-20: General Service Incandescent Lamps, Tier 2 #2 | EISA | ISSM |
| 2006 T-20: General Service Incandescent Lamps, Tier 2 #3 | EISA | ISSM |
| 2008 T-20: General Purpose Lighting -- 100 watt | EISA | ISSM |
| 2008 T-20: General Purpose Lighting -- 75 watt | EISA | ISSM |
| 2008 T-20: General Purpose Lighting -- 60 and 40 watt | EISA | ISSM |
| Unevaluated T-20: GSLs – Original Scope – Tier 2 | Future Fed Appliance: GSLs - Expanded Scope | Navigant Assumption |

# APPENDIX F. IND/AG GENERIC CUSTOM & EMERGING TECHNOLOGIES

## F.1 Ind/Ag Generic Custom Measure Forecast Methodology

### *F.1.1 Summary*

Generic custom (GC) measures in the industrial sector are projects that tend to be specific to an industry segment or production method. Table F-1 provides the inputs for the GC measures in the 2019 Study and the proceeding discussion details the assumptions and methodology used to derive these inputs.

**Table F-1. Industrial/Agriculture GC - Key Assumptions**

| Sector | Type | EUL Years | Savings | | Cost | | kW/kWh Savings Ratio |
|---|---|---|---|---|---|---|---|
| | | | kWh | therm | kWh | therm | |
| Ind | GC | 15 | 0.0842% | 0.1238% | $0.33 | $2.25 | 0.000195 |
| Ag | | | 0.1995% | 0.8996% | | | |

### *F.1.2 Applicability and Penetration*

Applicability of GC measures in the industrial and agricultural sectors is 100% because these measures are considered ubiquitous to all activities in all market segments. The approach to forecasting the penetration rate for GC measures changed for the 2019 model. In the 2017 Study (and prior years) penetration rates were held constant over the forecast horizon under the assumption that industrial facilities continually upgrade equipment and processes and therefore GC measures would be installed at the same rate as past program activity. Based on an analysis of EEStats data from 2013 through 2017 it was determined that GC savings are decreasing over time after separating out the contribution from RCx. As such, the penetration rate for GC measures was revised to show an annual decrease of approximately 3.3%, which we apply to both electricity and gas savings.

The team conducted a literature review to define an approach to estimate savings from GC measures:

- 2004-2005 Statewide Nonresidential Standard Performance Contract Program Measurement and Evaluation Study[177]
- 2006-2008 Evaluation Report for PG&E Fabrication, Process, and Manufacturing Contract Group[178]

[177] California Public Utilities Commission. Itron, Inc. CALMAC Study ID: SCE0220.01

[178] California Public Utilities Commission. Itron, Inc. February 3, 2010. CALMAC Study ID: CPU0017.01

- 2006-2008 Evaluation Report for the Southern California Industrial and Agricultural Contract Group[179]
- 2010-12 WO033 Custom Impact Evaluation Final Report[180]
- 2010-12 WO033 Custom Net-to-Gross Final Report[181]
- Final Report 2013 Custom Impact Evaluation, Industrial, Agricultural, and Large Commercial Submitted to California Public Utilities Commission[182]
- Final Report 2014 Custom Impact Evaluation Industrial, Agricultural, and Large Commercial, California Public Utilities Commission[183]
- 2013 Ex-post Efficiency Savings and Performance Incentive (ESPI) Performance Statement Report[184]
- 2014 Ex-Post ESPI Final Performance Statement Report[185]
- E-4807 Draft Resolution[186]
- CPUC EEStats and CEDARS data for net program savings for the 2013-2017 program cycles.

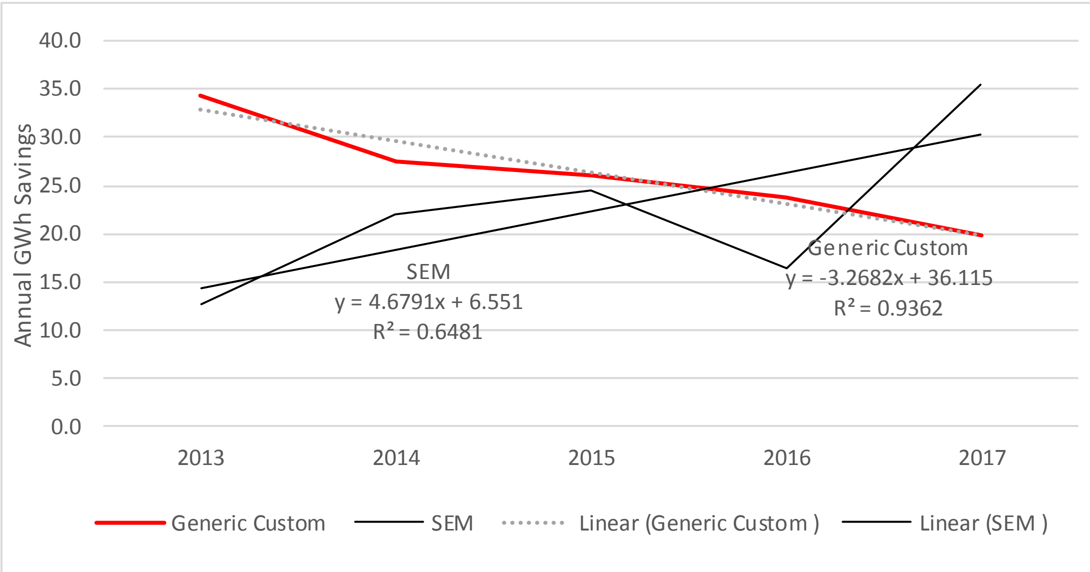
For the 2019 model, the definition of GC measures was revised from the 2017 Study to account for the following:

- There are a large number of measures that are defined but where any one measure contributes only a small percentage of portfolio savings (e.g., faucet aerator). These measures were aggregated, and the total impact was included within the generic measure category. A review of EEStats data for the 2013 – 2017 portfolio shows these smaller measures accounted for 9% of industrial sector and 8% of agricultural sector savings.
- The 2020 model separated out RCx savings from GC and considered RCx to be part of SEM savings because RCx is an integral part of effective SEM program designs. The 2017 Study included RCx as part of GC.
- The agricultural sector forecast is also impacted because the definition of which NAICS codes are to be included in the agricultural sector was redefined for the 2019 model to better align with the IEPR sector definition.

Considering these changes in the definition of the generic custom measure class, an analysis of data available through the EEStats portal for programs operating from 2013 through Q3 2017 indicating the GC savings have declined over time, while RCx savings have shown a positive trend as shown in Figure F-1.

[179] California Public Utilities Commission. Itron, Inc. February 3, 2010, CALMAC Study ID: CPU0018.01
[180] California Public Utilities Commission. Itron, Inc. July 14, 2014. 2010-12 WO033. CALMAC Study ID: CPU0072.01
[181] California Public Utilities Commission. Itron, Inc. September 24, 2014. CALMAC Study ID: CPU0072.03
[182] California Public Utilities Commission. Itron, Inc. July 17, 2015. CALMAC Study ID: CPU0147.01
[183] California Public Utilities Commission. Itron, Inc. April 29, 2016. CALMAC Study ID:
[184] CPUC, June 15, 2015
[185] CPUC, August 1, 2016
[186] Resolution E-4807, CPUC, December 15, 2016

Figure F-1. Comparison of GC and RCx Savings Trends




After separating out the RCx savings and considering small measures to be part of GC, Navigant completed the assessment of the contribution of GC measures to the total savings in the industrial and agricultural sectors. For the industrial sector, data available through the California EEStats portal[187] for programs operating from 2013 through 2017 was analyzed, and it was determined that GC measures contributed 22% of net electricity savings and 49% of natural gas savings. Based on this analysis it was determined that GC measures saved an average of 28.8 GWh annually in the industrial sector and 4.4 MMtherms over the 5-year period spanning 2013 through 2017. A GC UES multiplier was then developed by dividing these annual average energy savings by average sector consumption forecast for 2017 through 2030. This methodology defined GC UES multipliers of 0.08% for annual industrial sector electricity usage and 0.12% of annual natural gas usage. The UES factors in the 2019 model are smaller than the UES factors used in the 2017 Study because they included EEStats savings values for 2016 and 2017, which are considerably lower than savings realized in 2013 through 2015. As such, the industrial sector UES factors in the 2019 model for electricity and natural gas are 40% and 24% lower than the factors used in the 2017 Study.

For the agricultural sector, data available through the California EEStats portal[188] for programs operating from 2013 through 2017 was also analyzed, from which it was determined that GC measures contributed 35% of net electricity savings and 41% of net natural gas savings. Based on this analysis it was determined that GC measures save an average of 31 GWh and 1.0 MMtherms annually. A GC UES multiplier was then developed by dividing annual average energy savings by average sector consumption forecast for 2017 through 2030. This defined GC UES multipliers of 0.20% for annual agricultural sector electricity usage and 0.90% of annual natural gas usage. As with the industrial sector, the agricultural sector UES factors in the 2019 model are smaller than the UES factors used in the 2017 Study because they included EEStats savings values for 2016 and 2017, which are considerably lower than savings

187 http://eestats.cpuc.ca.gov/Default.aspx
188 http://eestats.cpuc.ca.gov/Default.aspx

realized in 2013 through 2015. As such, the agricultural sector UES factors in the 2019 model for electricity and natural gas are 28% and 25% lower than the factors used in the 2017 Study.

The agricultural sector forecast is also impacted because the definition of which NAICS codes are to be included in the agricultural sector was redefined for the 2019 model to better align with the IEPR sector definition. This redefinition required that some agricultural market segments previously used in the agricultural forecast be accounted for in the commercial sector, and market segments addressing water pumping potential be added to the agricultural sector. Table F-2 provides a comparison of agricultural sector NAICS used in the 2018 and 2019 models, while Table F-3 provides additional details on NAICS that define water pumping in the IEPR agricultural forecast. NAICS that were defined in the agricultural sector forecast in the 2018 (and prior) models but that are now considered part of the commercial sector are provided in Table F-5. This redefinition reduced the number of potential measures and savings applicability for the agricultural sector because water pumping usage is centered primarily on motor loads and therefore has a more limited set of EE options than the more diverse sectors shifted to the commercial sector, such as post-harvest processing. The net effect of lower UES values and a reduced set of market segments present in the agricultural sector is a significantly lower forecast for agricultural potential than was presented in the 2018 forecast.

**Table F-2. Comparison of Ag Secretor NAICS Between Models**

| 2019 Study | | 2017 Study | |
|---|---|---|---|
| **Definition** | **NAICS** | **Definition** | **NAICS** |
| Crop Production | 111 | Irrigated Agriculture | 1111, 1119, 1112, 1113 |
| | | Wineries and Vineyards | 111332 |
| Animal Production | 112 | Concentrated Animal Feeding Operation | 112 |
| | | Dairies | 112120 |
| Forestry and Logging | 113 | Not Included | |
| Fishing | 114 | Not Included | |
| Water Pumping | 221 | Not Included | |

**Table F-3. CEC Ag Sector Water Pumping NAICS**

| NAICS Category | NAICS Code | NAICS Code description | Utility | | |
|---|---|---|---|---|---|
| | | | PGE | SCE | SDGE |
| Water Supply | 221310 | Water Supply and Irrigation Systems | 71% | 2% | 93% |
| Water Supply | 221311 | Water pumping, municipal water supply | 5% | 96% | 4% |
| Irrigation | 221312 | Water pumping, agriculture irrigation | 24% | 2% | 3% |

**Table F-4. NAICS Codes Removed from the Ag Sector**

| Definition | NAICS | Percentage of 2018 Sector Usage |
|---|---|---|
| Post-Harvest Processing | 115114, 115111 | 16.5% |
| Refrigerated Warehouses | 493120 | 11.7% |

The GC UES multipliers for both the industrial and agricultural sectors was held constant throughout the forecast horizon and was applied to the consumption forecast for each market segment level throughout the forecast horizon using the following equation:

**Equation F-1. GC Segment Net Savings Potential**

$$GC\ segment\ level\ EE\ net\ savings\ potential = GC\ UES\ Multiplier\ x\ Annual\ Segment\ Consumption$$[189]

### *F.1.3 Other Input Assumptions*

Because GC measures tend to be larger capital investments that operate for long periods of time an EUL of 15 years was used in the forecasts.

A ratio of kW to kWh of 0.000195 was applied.

Finally, costs for electricity and natural gas savings are based on an analysis of industrial and agricultural programs operating throughout 2016. They are estimated at $0.33/kWh and $2.25/therm, and they are applied consistently across sectors and utilities.

## F.2 Ind/Ag Emerging Technology Measures

### *F.2.1 Summary*

In the context of the 2019 Study, emerging technologies (ETs) are new technologies that have demonstrated energy benefits to the industrial and agricultural sectors but are not yet widely adopted in the market. The team evaluated ETs at varying stages along the path to market readiness – some were just demonstrated in a laboratory or research setting, and others had been proven effective through pilot tests and are in early commercial adoption.

The 2019 Study is an update to the approach used for the 2017 Study. For the 2017 Study, Navigant identified approximately 1,100 potential ETs. These ETs were run through a screening process to rate energy technical potential, energy market potential, market risk, technical risk, and utility ability to impact market adoption. This process ultimately yielded 173 emerging technology processes[190] for final consideration within the model. For the 2019 Study Navigant reviewed the data source used in the 2017

[189] Electric (GWh) and natural gas (therm) from the 2017 IEPR forecast

[190] The emerging technologies represent a process for reducing energy consumption and not necessarily a specific technology.

Study to include measures that might have been added since the initial review, and updated measures originally identified for which there might be more recent data.

The following provides a description of the methodology used to evaluate the emerging technology market. The Assumptions and Methodology section discusses the process used to develop the model inputs for energy savings that are also summarized in Table F-5. Segment-specific electric and gas savings are consistently applied across all utilities. Costs, EUL, and the kW/kWh savings ratio are also universally applied.

**Table F-5. Industrial/Agriculture ET - Key Assumptions**

| Sector | Type | EUL Years | Savings | | Cost | | kW/kWh Savings Ratio |
|---|---|---|---|---|---|---|---|
| | | | kWh | therm | kWh | therm | |
| AIMS (Ind/Ag) | Emerging Technologies (ET) | 10 | 0.93% - 9.62% | 0.0% - 14.21% | $0.42 | $2.83 | 0.000195 |

### F.2.2 Eligibility and Participation

Our 2020 assessment of eligibility and participation began with quality assurance and quality control efforts to review the 2017 Study inputs to assess data entry, technology assessment, classification and scoring, as well as Excel formula references. Although no major changes were made, our review revealed a small number of instances for minor clarification or revisions to NAICS assignment or end use applicability of savings. For instance, a lighting measure was reclassified from the broader category of irrigated agriculture sector to the more specific greenhouses sector. In another, a formerly universally applied building facade measure was amended to eliminate therm savings from refrigerated warehouses, while another measure for waste heat recovery from refrigerated systems was updated to better reflect its potential applicability for heating of non-refrigerated spaces. In all, 13 measures received such minor fixes that resulted in no appreciable differences.

The process to evaluate eligibility and participation was to first identify the portfolio of ETs applicable to the industrial and agricultural sectors. Defining this portfolio was accomplished through the following steps:

1. Collect data to assemble a broad portfolio of ETs.
2. Characterize ETs based on various savings potential and risk criteria.

To collect data, the team reviewed the following web sources:

- Emerging Technologies Coordinating Council[191]
- CEC Publications Database[192]

[191] http://www.etcc-ca.com/reports

[192] http://www.energy.ca.gov/publications/searchReports.php?pier1=Buildings%20End-Use%20Energy%20Efficiency

- DOE Research and Development Projects[193]
- DOE Energy Efficiency & Renewable Energy Emerging Technologies Database[194]
- Broad web search which included independent research of topics and keywords that seemed of relevance to the team based on the initial web scrape results of the other sources.

This process yielded an Excel-based database with approximately 1,100 different ETs that that captured several details including the name of the ET, a description of the technology, and key dates in the research process. Web scraping is an effective method to gather a broad wealth of information. However, it does not filter out irrelevant information. Therefore, the team refined the database by deleting certain entries or by enhancing information on select other ETs with additional research data from identified sources. As discussed under the appendix section on GC measures, the definition of agricultural sector was revised to better align with the IEPR agricultural sector definition. This included consideration of ETs most applicable to water pumping measures including:

- Ultra-Efficient and Power-Dense Motors
- Efficient Electronics Through Measurement and Communication, National Lab Buildings Energy Efficiency Research Projects
- Compressed Air to Blower Air
- Automated Hybrid Demand Control and Demand Response in Commercial Accounts
- Increasing the Market Acceptance of Smaller CHP Systems

Once the portfolio of ETs was prepared, each ET was characterized to determine if it is relevant to the industrial or agricultural sector and define how each ET might impact each market segment within those sectors. The team gave each relevant technology a unique ID and characterized it with the following criteria. Criteria were also weighted to prioritize their relevance as shown in Table E-3.

- Classification Information
  - Fuel savings (electricity/gas)
  - End-use
  - NAICS sector (3 or 4 digit)
  - Energy savings as a percent of sector consumption
- Evaluation Criteria (used to calculate overall impact evaluation score)
  - Energy technical potential
  - Energy market potential
  - Market risk
  - Technical risk

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[193] https://energy.gov/eere/amo/research-development-projects

[194] https://energy.gov/eere/buildings/emerging-technologies

- Utility ability to impact outcome
- Non-energy benefits

The team gave each ET a score of 1 through 5 for each evaluation criteria, which were then weighted and summed to calculate the overall impact evaluation score. ETs that earn a higher score are expected to have a greater impact (i.e., greater energy savings) on the agricultural or industrial sectors. Table F-6 gives the scoring and weighting information for the evaluation criteria. The process ultimately yielded 173 emerging technology processes which were used to forecast the savings potential for ETs.

**Table F-6. Emerging Technology Evaluation Criteria**

| Technology Characteristics | Weight | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Energy Technical Potential | 3 | Low | Low | Medium | High | High |
| Energy Market Potential | 3 | Low | Low | Medium | High | High |
| Market Risk | 2 | High Risk | High Risk | Medium Risk | Low Risk | Low Risk |
| Technical Risk | 2 | High Risk | High Risk | Medium Risk | Low Risk | Low Risk |
| Utility Ability to Impact Market | 1 | Private sector will succeed without utility involvement | Utility is unlikely to be critical to adoption | Utility is likely to accelerate adoption | Utility is important in accelerating adoption | Utility is essential for catalyzing market |
| Non-Energy Benefits (NEBs) | 1 | Few or none NEBs | Some modest NEBs likely | Significant benefits, but difficult to quantify / not understood | 1 or 2 quantified, well-documented NEBs | Extensive, quantified, well-understood NEBs |

*Source: Navigant analysis*

The characterization process worked to distinguish between energy technical potential and energy market potential. The energy technical potential evaluates the energy savings of the specific technology, relative to the energy consumption of the baseline equivalent technology. The energy market potential takes a broader view and is a measure of the energy savings potential of that ET relative to the entire market energy consumption. ETs that have a high energy technical potential, but low energy market potential include technologies that drastically improve efficiency of a certain technology but have limited market application.

### *F.2.3 Savings*

To estimate savings, the team calculated multipliers for each ET. These multipliers represent information on the total energy savings potential of the ET and other influential market data. The following formula was used to calculate the multiplier for each emerging technology that is then applied to a specific market segment and end-use energy consumption.

**Equation F-2. Emerging Technology Multiplier**

$$M_{e,i,j} = T_e \times E_{i,j} \times MT_j \times TW_j$$

Where:

| | | |
|---|---|---|
| $M_{e,i,j}$ | = | multiplier for each ET, *e*, applied to end-use, *i*, and segment, *j* |
| *e* | = | subscript indicating the ET |
| *i* | = | subscript indicating the end-use |
| *j* | = | subscript indicating the market segment |
| $T_e$ | = | technology energy savings percentage for ET, *e* |
| $E_{i,j}$ | = | percentage of segment *j* energy attributable to end-use, *i* |
| $MT_j$ | = | market trajectory for segment *j* |
| $TW_j$ | = | segment energy consumption trend weight for segment *j* |

- The technology energy savings percentage, $T_e$, was identified during the ET characterization process.
- The segment end-use percentage, $E_{i,j}$, is derived from California market data.[195]
- The market trajectory for each sector, $MT_j$ , is a value between 0 and 1 and is intended to define if a market segment is likely to stay active in California long enough for the ET to move up the adoption curve to a point where they make an impact on segment energy use. No specific timeline was defined, however the team assigned segments a weight:[196] For the 2019 model all measures have a market trajectory of 1 as a result of discussions with CEC in which it was determined that IEPR segment forecasts include considerations for reductions in electricity and natural gas that result from industries relocating outside of California, including offshoring.
    - 0.33. Indicates a segment is likely to move or remain offshore. It is not expected to benefit from the ET adoption cycle.
    - 0.67. Indicates a segment is close to the tipping point of moving out of California or the US. It is at risk of not benefitting from the ET adoption cycle.
    - 1.0. Indicates a segment is likely to remain in the California. It is expected to benefit from the ET adoption cycle.

The values of all applicable ET multipliers were summed for each market segment to define an ET UES multiplier, provided in Table F-7, to forecast segment level potential net savings using the following equation:

**Equation F-3. Emerging Technology Segment Net Savings Potential**

ET segment level EE net savings potential = ET UES Multiplier x Annual Segment Consumption[197]

**Table F-7. Emerging Technologies UES Multipliers by Segment and Fuel**

| Segment | UES Multiplier (kWh) | UES Multiplier (therm) |
|---|---|---|
| Ind - Petroleum | 0.17% | 1.22% |
| Ind – Food | 1.58% | 9.18% |
| Ind - Electronics | 2.45% | 4.10% |
| Ind - Stone-Glass-Clay | 0.97% | 0.99% |

[195] Energy use trend analysis provided by CEC.
[196] Sirkin, H. et al. *U.S. Manufacturing Nears the Tipping Point*, The Boston Consulting Group, March 2012.
[197] Electric (GWh) and natural gas (therm) from the 2017 IEPR Forecast

| Segment | UES Multiplier (kWh) | UES Multiplier (therm) |
|---|---|---|
| Ind - Chemicals | 0.93% | 9.19% |
| Ind - Plastics | 1.40% | 5.37% |
| Ind - Fabricated Metals | 1.45% | 14.21% |
| Ind - Primary Metals | 0.26% | 8.61% |
| Ind - Industrial Machinery | 2.90% | 5.62% |
| Ind - Transportation Equipment | 1.18% | 1.94% |
| Ind - Paper | 0.71% | 1.87% |
| Ind - Printing & Publishing | 0.99% | 1.02% |
| Ind - Textiles | 1.42% | 2.85% |
| Ind - Lumber & Furniture | 1.28% | 2.74% |
| Ind - All Other Industrial | 4.52% | 4.58% |
| Ag - Irrigated Agriculture, vineyards, forestry and greenhouses | 9.62% | 0.00% |
| Ag - Dairies, fishing, hunting | 0.96% | 0.44% |
| Ag - Water pumping | 3.40% | 0.00% |

*Source: Navigant analysis*

The ET UES multipliers were held constant throughout the 2019 Study forecast horizon. The team developed a reference and aggressive case forecast based on a CAGR by which the portfolio of ETs is expected to be adopted by the market (i.e., penetration). The reference case assumes a CAGR of 3.25%, achieving 8.6% market penetration within the forecast horizon ending in 2030. The aggressive case assumes a CAGR of 4.25%.

### *F.2.4 Other Input Assumptions*

The model uses a universal EUL of 10 years to accommodate the broad range of emerging technology adoption curves.

A ratio of kW to kWh of 0.000195 was applied.

Finally, costs for electricity and natural gas savings are estimated at $0.42/kWh and $2.83/therm and are applied consistently for all utilities and across all industrial and agricultural sectors. Costs are based on an analysis of industrial and agricultural programs operating throughout 2016 and reflect costs that are higher than average for the portfolio based on the expectation that ETs will be more expensive than more established technologies, and so will require higher incentives and EM&V costs to verify performance.

# APPENDIX G. FINANCING METHODOLOGY AND INPUTS

Financing has the potential to break through a number of market barriers that have limited the widespread market adoption of cost-effective energy efficiency (EE) measures. The PG Model is able to estimate the added effects of introducing EE financing on EE market potential and how shifting assumptions about financing affect the potential energy savings.

No updates relative to the 2017 Study have been made to the methodology or data inputs related to financing in the 2019 Study. This appendix replicates the same explanation of methods and inputs as the 2017 Study final report.

Examples of market barriers that can slow EE adoption[198] include:

- **Information Search Cost** - Even when information of new technologies is publicly available, it is costly for consumers to learn about the innovation.
- **Lack of Capital Access and Liquidity Constraint -** Lack of upfront capital or credit for EE investments.
- **Un-internalized Externalities** - Energy is heavily subsidized; consumers are not aware of the true cost of energy.
- **Split Incentives** - Party making the efficiency investment decision is not the party benefitting from the decision.
- **Hassle Factor -** This includes efforts invested in completing transactions such as the application process.
- **Behavioral Failures** - Consumers are not perfectly rational, resulting in consumer behavior inconsistent with utility maximization or energy cost minimization.

## G.1 Financing Programs Background

California financing programs address some of these market barriers, such as lack of capital access and liquidity. Per the CPUC's PY2014 Finance Residential Market Baseline Study Report[199], more than half of homeowners (54%) believe that the higher upfront costs present a barrier to EE projects and one-third of respondents stated that financing could help reduce that barrier.

Furthermore, there is research to suggest that financing programs encourage deeper energy savings per project since consumers can take on larger projects with higher associated savings, beyond what they could have otherwise afforded in the absence of financing.[200] Among homeowners who made an energy upgrade and used financing, nearly three-quarters using financing indicated that the financing allowed

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[198] Jaffe, Newell, and Stavins. Economics of Energy Efficiency. Encyclopedia of Energy Vol. 2: 79-89. 2004.

[199] PY2014 Finance Residential Market Baseline Study Report. Opinion Dynamics Corporation and Dunsky Energy Consulting. March 2016

[200] Southwest Energy Efficiency Project. Energy Efficiency Finance Options and Roles for Utilities. October 2011.

them to do a larger project or purchase higher quality equipment than what they would have done on their own.[201] For the non-residential sector, 83% of on-bill financing (OBF) loans were for projects exceeding 10% energy savings.[202]

Financing may also reduce the hassle factor barrier that may affect a consumer's willingness to take on an EE project. In a California study of homeowners who chose to use financing, a clear majority (88%) felt that financing was the most convenient option for them.[203]

For non-residential customers, qualified customers can access 0% OBF through a statewide program administered by the investor-owned utilities (IOUs). The OBF programs use alternative underwriting criteria that considers utility bill repayment history as a measure of creditworthiness[204]. Participating in OBF and repaying the financed cost through a utility bill may be easier to understand and more convenient than applying for and repaying a conventional financing option.

Because a significant proportion of customers (46%) indicated a preference for 0% financing over rebates (34%),[205] PG&E is testing an OBF alternative pathway that will be paired with metered energy data instead of an incentive.[206] Because the incentive applications are where most problems occur in the application process, the alternate pathway program may further reduce the complexity and hassle barrier that some customers may associate with participating in utility EE programs.[207]

## G.2 Impact of Financing on Consumer Economics

Financing allows consumers to use private capital to fund EE projects; borrowers avoid the upfront cost and repay the project cost over time. We can evaluate the attractiveness of a financing option by looking at the annual cash flows for an efficient measure, compared to an efficient measure that is financed, and comparing the net present value of the options.

The net present value (NPV) is calculated by assigning costs and benefits, discounting future costs and benefits (future value, or FV) by an appropriate discount rate (i), and subtracting the present value total costs from the present value total benefits.[208]

To discount future payments, we apply the annual consumer discount rate ($i$) per the equation below, where $n$ is the number of years:

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[201] PY2014 Finance Residential Market Baseline Study Report. Opinion Dynamics Corporation and Dunsky Energy Consulting. March 2016

[202] Disposition approving Advice Letter 3697-G /4812-E, 3697-G-A/4812-E-A, PG&E's On Bill Financing Alternative Pathway Program, as a High Opportunity Program. July 12, 2016.

[203] PY2014 Finance Residential Market Baseline Study Report. Opinion Dynamics Corporation and Dunsky Energy Consulting. March 2016

[204] Financing Energy Improvements on Utility Bills. Technical Appendix Case Studies. State and Local Energy Efficiency Action Network (SEE Action). May 2014.

[205] California 2010-2012 On-Bill Financing Process Evaluation and Market Assessment (CALMAC ID CPU0056.01),

[206] Commercial customers can receive up to a $100,000 loan for 5 years, and government can receive up to a $250,000 loan for 10 years. The alternative path will leverage existing infrastructure as well as the existing on bill financing program's revolving loan fund.

[207] 2010-2012 CA IOU On-bill Financing Process Evaluation and Market Assessment. May 2012.

[208] OMB Circular A-94. Available at: https://www.wbdg.org/FFC/FED/OMB/OMB-Circular-A94.pdf

**Equation G-1. Present Value Equation**

$$Present\ Value\ = Future\ Value\ \times (1+i)^{-n}$$

We can evaluate the present value of an EE measure over the useful life of the equipment by comparing the NPV of the hypothetical costs of the equipment and energy. For example, Table G-1 shows the present value cost of a base efficiency technology ($1,000) purchased in year 0, followed by energy costs for that unit of $200 annually for 10 years. The total cash outflows are discounted by the assumed consumer discount rate, which for this example is 7%. The net present cost of the base technology is $2,405.

The next calculation shows the net present cost of the efficient technology, which in this case costs $1,250 to the consumer upfront after a 50% rebate on the incremental cost of the efficient technology whose original cost was $,1500 (i.e., $1,500 – [($1,500-$1,000) x 50%] = $1,250). The annual energy cost of the efficient technology is $125 per year. The total cash outflows are discounted by the same consumer discount rate (7%), yielding a net present cost for the efficient technology is $2,128. This total cost is less than the base technology.

Finally, the third calculation shows the net present cost of the efficient technology after financing. The efficient technology costs $1,250 with the utility incentive. Assuming a consumer uses an EE loan at 4% for 10 years, the equipment and financing costs are spread over 10 years at $148 per year. The annual energy cost of the efficient technology financed is still $125 per year. The total cash outflows are discounted by the same consumer discount rate (7%), yielding a net present cost for the efficient technology with financing of $1,992. This total cost is less than the base model and less than the efficient technology without financing.

**Table G-1. Example Present Value Comparisons for Base and Efficient Technologies and Financing**

| Base Technology | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| Base Equipment Cost | $1,000 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| Energy Cost | $0 | $200 | $200 | $200 | $200 | $200 | $200 | $200 | $200 | $200 | $200 |
| Total Cash Out | $1,000 | $200 | $200 | $200 | $200 | $200 | $200 | $200 | $200 | $200 | $200 |
| Present Value | $1,000 | $187 | $175 | $163 | $153 | $143 | $133 | $125 | $116 | $109 | $102 |
| **NPV Cost** | **$2,405** | | | | | | | | | | |

| Efficient Technology | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| Efficient Equipment Cost | $1,250 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| Energy Cost | $0 | $125 | $125 | $125 | $125 | $125 | $125 | $125 | $125 | $125 | $125 |
| Total Cash Out | $1,250 | $125 | $125 | $125 | $125 | $125 | $125 | $125 | $125 | $125 | $125 |
| Present Value | $1,250 | $117 | $109 | $102 | $95 | $89 | $83 | $78 | $73 | $68 | $64 |
| **NPV Cost** | **$2,128** | | | | | | | | | | |

| Efficient Technology with Financing | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| Equipment Cost Financed | $148 | $148 | $148 | $148 | $148 | $148 | $148 | $148 | $148 | $148 | $0 |
| Energy Cost | $0 | $125 | $125 | $125 | $125 | $125 | $125 | $125 | $125 | $125 | $125 |
| Total Cash Out | $148 | $273 | $273 | $273 | $273 | $273 | $273 | $273 | $273 | $273 | $125 |
| Present Value | $148 | $255 | $239 | $223 | $208 | $195 | $182 | $170 | $159 | $149 | $64 |
| **NPV** | **$1,992** | | | | | | | | | | |

The modified cash flows feed into the calculation of consumer willingness (described earlier in Section 2.1.1.4) by representing the effective present value of financing to the customer as a fraction of the upfront cost. Increasing willingness results in higher adoption of EE measures and thus more savings. The model does not estimate technical or economic potential of financing, only market potential.

The CPUC has recognized financing as an EE resource program.[209] However, as of March 2017 (when research for this study was finalized), no impact evaluations have been published to provide verified savings estimates. In the absence of impact studies, the input data to model financing was developed by Navigant leverage available market studies.

## G.3 Residential Inputs

To develop the residential financing cash flow model inputs, Navigant considered the achievements to date of the existing Regional Finance Programs, and the key financing terms for the Residential Energy Efficiency Loan (REEL) Program lenders[210].

**Table G-2. 2013-2015 Achievements by Regional Financing Program**

| Program | Start Date | Utility | Min. FICO | Avg. Rate | Avg. Term (yrs.) | Avg. Amount ($) | Loans to Date |
|---|---|---|---|---|---|---|---|
| Golden State Financing Authority (GSFA) Energy Retrofit Program | Sep-12 | PG&E | 640 | 6.50% | 15 | 25,612 | 201 |
| emPower Central Coast | Nov-11 | SCE, SCG, PG&E | 590 | 5.85% | 14.5 | 20,809 | 52 |
| SoCalREN Home Energy Loans | Dec-13 | SCE, SCG | 660 | 5.87% | 9.5 | 18,087 | 100 |

*Source: Regional* Finance *Program Attribution and Cost Effectiveness Study Evaluation Plan.*

### *G.3.1 Interest Rate*

The interest rate is the percentage of the principal that a lender charges to a borrower for taking out a loan. Navigant considered the average discount rates of the Regional Financing Programs, and the range of interest rates available to borrowers of the REEL Program. Based on this information, Navigant assumed an interest rate of 6% for REELs in the cash flow model.

### *G.3.2 Loan Term*

The loan term is the length of time of the loan agreement. REEL Program loans offer terms up to 15 years.[211] The average term of the Regional Finance Program loans ranges from 9.5 to 15 years. Based on this information, Navigant assumed a loan term of 12 years in the cash flow model.

### *G.3.3 Consumer Discount Rate*

The discount rate is the rate by which future cash flows are discounted to determine the present value of the payment stream. Using a consumer discount rate allows multiple payment streams to be compared in

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[209] CPUC Decision 12-05-2015, May 8, 2012 and Decision Approving 2013-14 Energy Efficiency Programs and Budgets, October 9, 2012

[210] REEL Lenders Chart. Available at: http://www.thecheef.com/lender-chart

[211] Ibid.

the same timeframe. A low discount rate indicates that the value of future cash flows is low compared to the value now. We use the real discount rate, instead of the nominal discount rate, to eliminate the effect of inflation.

Estimating the discount rate for residential customers is not straightforward, and may vary by demographic factors such as credit score, income, race, and household size. The Office of Management and Budget (OMB) has prescribed a discount rate of 7% for benefit-cost analysis, and the US Department of Energy (DOE) uses 3% and 7% in the analyses for residential appliance standards.[212] Other government organizes use discount rates in this range. For example, the Northwest Power and Conservation Council, which used 3% in the Seventh Power and Conservation Plan, and a lighting study by the DOE calculated a consumer discount rate of 5.6%.

However, the estimated discount rate for residential customers may be much higher than the range of 3-7% used in regulatory analysis. For example, one study looked at the observed discount rates for individuals and their preferences for EE and found that “a simple fact emerges that in making decisions which involve discounting over time, individuals behave in a manner which implies a much higher discount rate than can be explained in terms of the opportunity costs of funds available in credit markets.”[213] Based on these considerations, Navigant used a consumer discount rate of 7% for the financing model.

### *G.3.4 Eligible Population*

Navigant updated the residential population eligibility in the 2015 Potential and Goals Study using Experian Consumer Credit data, accessed in November 2014. The 2015 Study identified the residential population eligibility at 98%. Like the 2015 Potential Study, Navigant assumes that residential customers with FICO credit scores above 580 are eligible for financing, and that 98% of single-family customers are eligible for financing. The credit requirement aligns with the REEL program, which requires a minimum FICO score of 580 with income verification, and a FICO score of 640 without income verification.

Following the approach to eligibility assumptions for the multifamily sector in the 2013 and 2015 Potential Studies, Navigant estimated multifamily sector eligibility to be 5% based on the proportion of the segment that is affordable housing.[214]

In summary, the Navigant team used the following inputs for the residential cash flow model:

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[212] For example, see: http://www.gao.gov/assets/690/682586.pdf

[213] Hausman, Jerry. Individual Discount Rates and the Purchase and Utilization of Energy-Using Durables. The Bell Journal of Economics, Vol. 10, No. 1. Spring 1979.

[214] The affordable housing market segment is the current focus of the proposed EE financing programs. Due to legal and regulatory issues, OBR is not a viable option except master-metered properties.

**Table G-3. Key Inputs to Residential Financing Cash Flow Model**

| Model Input | Assumption | Source |
|---|---|---|
| Interest Rate | 6% | Navigant analysis of California IOU financing programs data[1] |
| Loan Term | 12 years | Navigant analysis of California IOU financing programs data[1] |
| Discount Rate | 7% | OMB Circular No. A-94 |
| Eligible Population | 98% of single-family customers<br>5% of multifamily customers | 2015 California Potential and Goals Study |

*Source: Navigant analysis of the Regional Finance Program Attribution and Cost-effectiveness Study: Evaluation Plan*

## G.4 Commercial Inputs

### *G.4.1 Interest Rate*

Non-residential customers can access 0% financing through the statewide OBF program. The projects are designed to be bill neutral, such that the monthly payment is less than the projected energy savings.[215] Based on these guidelines, Navigant assumed an interest rate of 0% in the cash flow model for OBF loans for the commercial and industrial sector.

### *G.4.2 Loan Term*

The OBF program offers 0% financing for loans up to 5 years for the small and large commercial sector, and up to 10 years for the government sector. Given that our model does not distinguish between the commercial and government sector, we apply a single assumption for the commercial sector.

### *G.4.3 Consumer Discount Rate*

For non-residential customers, the discount rate is the weighted average cost of capital for companies (WACC) who use both debt and equity to fund their investments.

In summary, the Navigant team used the following inputs for the commercial and industrial cash flow model:

[215] SEEaction OBF report, Appendix A
https://www4.eere.energy.gov/seeaction/system/files/documents/publications/chapters/onbill_financing_appendix.pdf

**Table G-4. Key Inputs to Commercial and Industrial Financing Cash Flow Model**

| Model Input | Assumption | Source |
|---|---|---|
| Interest Rate | 0% | California OBF program terms |
| Loan Term | 5 years | California OBF program terms |
| Discount Rate | 5.8% | 2016 LBNL Commercial Discount Rate Estimation for Efficiency Standards |

# APPENDIX H. DETAILED SCENARIO RESULTS

## H.1 PG&E

Table H-1. PG&E Electric Energy Savings (GWh/year)

| Year | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PG Reference Scenario** | | | | | | | | | | | |
| Equipment Rebates* | 130 | 166 | 187 | 177 | 175 | 168 | 153 | 146 | 143 | 131 | 135 |
| BROs | 180 | 193 | 204 | 216 | 228 | 241 | 254 | 267 | 279 | 292 | 306 |
| ***Incentive Programs (Subtotal)*** | ***310*** | ***359*** | ***391*** | ***393*** | ***403*** | ***409*** | ***407*** | ***413*** | ***422*** | ***423*** | ***440*** |
| C&S** | 646 | 642 | 629 | 631 | 599 | 578 | 537 | 499 | 447 | 390 | 331 |
| **Total** | **956** | **1,001** | **1,020** | **1,024** | **1,002** | **986** | **944** | **913** | **870** | **813** | **771** |
| **PG Alternative Scenario 1** | | | | | | | | | | | |
| Equipment Rebates* | 173 | 206 | 201 | 189 | 184 | 177 | 161 | 154 | 149 | 137 | 140 |
| BROs | 180 | 193 | 204 | 216 | 228 | 241 | 254 | 267 | 279 | 292 | 306 |
| ***Incentive Programs (Subtotal)*** | ***353*** | ***399*** | ***405*** | ***405*** | ***412*** | ***418*** | ***415*** | ***421*** | ***429*** | ***428*** | ***445*** |
| C&S** | 646 | 642 | 629 | 631 | 599 | 578 | 537 | 499 | 447 | 390 | 331 |
| **Total** | **999** | **1,041** | **1,034** | **1,036** | **1,011** | **995** | **953** | **920** | **876** | **818** | **776** |
| **PG Alternative Scenario 2** | | | | | | | | | | | |
| Equipment Rebates* | 110 | 151 | 148 | 140 | 139 | 137 | 128 | 126 | 131 | 120 | 123 |
| BROs | 180 | 193 | 204 | 216 | 228 | 241 | 254 | 267 | 279 | 292 | 306 |
| ***Incentive Programs (Subtotal)*** | ***290*** | ***344*** | ***352*** | ***356*** | ***367*** | ***378*** | ***382*** | ***393*** | ***410*** | ***412*** | ***429*** |
| C&S** | 646 | 642 | 629 | 631 | 599 | 578 | 537 | 499 | 447 | 390 | 331 |
| **Total** | **936** | **986** | **981** | **987** | **966** | **956** | **920** | **892** | **857** | **801** | **760** |
| **PG Alternative Scenario 3** | | | | | | | | | | | |
| Equipment Rebates* | 134 | 170 | 190 | 179 | 176 | 168 | 153 | 147 | 144 | 132 | 136 |
| BROs | 232 | 246 | 263 | 280 | 301 | 339 | 365 | 395 | 431 | 473 | 524 |
| ***Incentive Programs (Subtotal)*** | ***365*** | ***416*** | ***453*** | ***460*** | ***477*** | ***507*** | ***518*** | ***542*** | ***575*** | ***606*** | ***660*** |
| C&S** | 646 | 642 | 629 | 631 | 599 | 578 | 537 | 499 | 447 | 390 | 331 |
| **Total** | **1,012** | **1,058** | **1,082** | **1,090** | **1,076** | **1,085** | **1,055** | **1,041** | **1,022** | **995** | **991** |
| **PG Alternative Scenario 4** | | | | | | | | | | | |
| Equipment Rebates* | 187 | 217 | 210 | 197 | 190 | 182 | 167 | 159 | 155 | 143 | 146 |
| BROs | 232 | 246 | 263 | 280 | 301 | 339 | 365 | 395 | 431 | 473 | 524 |
| ***Incentive Programs (Subtotal)*** | ***418*** | ***463*** | ***473*** | ***477*** | ***491*** | ***521*** | ***531*** | ***554*** | ***586*** | ***616*** | ***670*** |
| C&S** | 646 | 642 | 629 | 631 | 599 | 578 | 537 | 499 | 447 | 390 | 331 |
| **Total** | **1,065** | **1,105** | **1,102** | **1,108** | **1,090** | **1,099** | **1,068** | **1,053** | **1,034** | **1,006** | **1,001** |
| **Low Income Programs** | | | | | | | | | | | |
| **PG Reference Scenario** | 4.68 | 5.14 | 5.29 | 5.24 | 5.35 | 5.47 | 5.57 | 5.65 | 5.67 | 5.72 | 5.66 |
| **PG Alternative Scenario 1** | 4.68 | 5.14 | 5.29 | 5.24 | 5.35 | 5.47 | 5.57 | 5.65 | 5.67 | 5.72 | 5.66 |
| **PG Alternative Scenario 2** | 4.68 | 5.14 | 5.29 | 5.24 | 5.35 | 5.47 | 5.57 | 5.65 | 5.67 | 5.72 | 5.66 |
| **PG Alternative Scenario 3** | 4.81 | 5.31 | 5.31 | 5.43 | 5.56 | 5.69 | 5.78 | 5.82 | 5.84 | 5.78 | 5.71 |
| **PG Alternative Scenario 4** | 4.81 | 5.31 | 5.31 | 5.43 | 5.56 | 5.69 | 5.78 | 5.82 | 5.84 | 5.78 | 5.71 |

*Excludes Low Income Programs **Includes interactive effects

**Table H-2. PG&E Demand Savings (MW)**

| Year | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PG Reference Scenario** | | | | | | | | | | | |
| Equipment Rebates* | 30.1 | 36.0 | 38.9 | 37.6 | 38.2 | 37.5 | 35.6 | 34.7 | 34.2 | 32.0 | 32.3 |
| BROs | 34.4 | 36.9 | 39.0 | 41.1 | 43.3 | 45.8 | 48.2 | 50.5 | 52.7 | 55.0 | 57.5 |
| ***Incentive Programs (Subtotal)*** | ***64.5*** | ***72.9*** | ***77.9*** | ***78.7*** | ***81.6*** | ***83.3*** | ***83.7*** | ***85.2*** | ***86.9*** | ***87.0*** | ***89.8*** |
| C&S** | 131.0 | 136.2 | 134.4 | 140.6 | 135.1 | 130.4 | 122.5 | 115.0 | 104.2 | 95.3 | 86.0 |
| **Total** | **195.5** | **209.1** | **212.3** | **219.3** | **216.7** | **213.7** | **206.2** | **200.3** | **191.1** | **182.4** | **175.8** |
| **PG Alternative Scenario 1** | | | | | | | | | | | |
| Equipment Rebates* | 38.3 | 45.1 | 43.3 | 41.0 | 40.6 | 39.9 | 37.7 | 36.6 | 35.8 | 33.4 | 33.6 |
| BROs | 34.4 | 36.9 | 39.0 | 41.1 | 43.3 | 45.8 | 48.2 | 50.5 | 52.7 | 55.0 | 57.5 |
| ***Incentive Programs (Subtotal)*** | ***72.7*** | ***82.0*** | ***82.3*** | ***82.1*** | ***83.9*** | ***85.6*** | ***85.9*** | ***87.1*** | ***88.5*** | ***88.4*** | ***91.1*** |
| C&S** | 131.0 | 136.2 | 134.4 | 140.6 | 135.1 | 130.4 | 122.5 | 115.0 | 104.2 | 95.3 | 86.0 |
| **Total** | **203.6** | **218.2** | **216.7** | **222.7** | **219.0** | **216.0** | **208.3** | **202.2** | **192.8** | **183.7** | **177.1** |
| **PG Alternative Scenario 2** | | | | | | | | | | | |
| Equipment Rebates* | 26.3 | 34.6 | 33.7 | 32.3 | 32.5 | 32.5 | 31.4 | 31.0 | 31.6 | 29.7 | 30.1 |
| BROs | 34.4 | 36.9 | 39.0 | 41.1 | 43.3 | 45.8 | 48.2 | 50.5 | 52.7 | 55.0 | 57.5 |
| ***Incentive Programs (Subtotal)*** | ***60.7*** | ***71.5*** | ***72.7*** | ***73.4*** | ***75.9*** | ***78.3*** | ***79.6*** | ***81.5*** | ***84.3*** | ***84.7*** | ***87.5*** |
| C&S** | 131.0 | 136.2 | 134.4 | 140.6 | 135.1 | 130.4 | 122.5 | 115.0 | 104.2 | 95.3 | 86.0 |
| **Total** | **191.7** | **207.7** | **207.1** | **214.0** | **210.9** | **208.7** | **202.0** | **196.6** | **188.6** | **180.0** | **173.6** |
| **PG Alternative Scenario 3** | | | | | | | | | | | |
| Equipment Rebates* | 30.8 | 36.8 | 39.6 | 38.1 | 38.6 | 37.9 | 35.9 | 34.9 | 34.3 | 32.1 | 32.3 |
| BROs | 41.9 | 44.4 | 47.4 | 50.5 | 54.0 | 59.6 | 64.0 | 69.2 | 75.4 | 82.7 | 91.4 |
| ***Incentive Programs (Subtotal)*** | ***72.7*** | ***81.1*** | ***87.0*** | ***88.6*** | ***92.6*** | ***97.5*** | ***99.9*** | ***104.2*** | ***109.8*** | ***114.8*** | ***123.7*** |
| C&S** | 131.0 | 136.2 | 134.4 | 140.6 | 135.1 | 130.4 | 122.5 | 115.0 | 104.2 | 95.3 | 86.0 |
| **Total** | **203.7** | **217.4** | **221.4** | **229.1** | **227.7** | **227.9** | **222.3** | **219.2** | **214.0** | **210.1** | **209.7** |
| **PG Alternative Scenario 4** | | | | | | | | | | | |
| Equipment Rebates* | 40.1 | 46.8 | 44.9 | 42.2 | 41.6 | 40.8 | 38.3 | 37.1 | 36.1 | 33.5 | 33.5 |
| BROs | 41.9 | 44.4 | 47.4 | 50.5 | 54.0 | 59.6 | 64.0 | 69.2 | 75.4 | 82.7 | 91.4 |
| ***Incentive Programs (Subtotal)*** | ***82.0*** | ***91.2*** | ***92.3*** | ***92.7*** | ***95.6*** | ***100.4*** | ***102.4*** | ***106.3*** | ***111.6*** | ***116.1*** | ***124.9*** |
| C&S** | 131.0 | 136.2 | 134.4 | 140.6 | 135.1 | 130.4 | 122.5 | 115.0 | 104.2 | 95.3 | 86.0 |
| **Total** | **213.0** | **227.4** | **226.7** | **233.3** | **230.7** | **230.7** | **224.8** | **221.3** | **215.8** | **211.5** | **210.9** |
| **Low Income Programs** | | | | | | | | | | | |
| **PG Reference Scenario** | 6.25 | 6.93 | 6.89 | 6.62 | 6.56 | 6.53 | 6.50 | 6.48 | 6.47 | 6.45 | 6.35 |
| **PG Alternative Scenario 1** | 6.25 | 6.93 | 6.89 | 6.62 | 6.56 | 6.53 | 6.50 | 6.48 | 6.47 | 6.45 | 6.35 |
| **PG Alternative Scenario 2** | 6.25 | 6.93 | 6.89 | 6.62 | 6.56 | 6.53 | 6.50 | 6.48 | 6.47 | 6.45 | 6.35 |
| **PG Alternative Scenario 3** | 6.50 | 7.25 | 7.04 | 6.93 | 6.86 | 6.83 | 6.80 | 6.78 | 6.73 | 6.62 | 6.52 |
| **PG Alternative Scenario 4** | 6.50 | 7.25 | 7.04 | 6.93 | 6.86 | 6.83 | 6.80 | 6.78 | 6.73 | 6.62 | 6.52 |

*Excludes Low Income Programs
**Includes interactive effects

 

### Table H-3. PG&E Gas Energy Savings (MMtherm/year)

| Year | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PG Reference Scenario** | | | | | | | | | | | |
| Equipment Rebates* | 5.2 | 6.7 | 7.4 | 9.7 | 9.8 | 9.6 | 9.1 | 9.1 | 9.0 | 8.4 | 8.9 |
| BROs | 6.8 | 7.2 | 7.5 | 7.9 | 8.2 | 8.6 | 9.1 | 9.5 | 9.9 | 10.4 | 10.9 |
| ***Incentive Programs (Subtotal)*** | ***12.1*** | ***13.9*** | ***15.0*** | ***17.6*** | ***18.1*** | ***18.2*** | ***18.2*** | ***18.6*** | ***18.9*** | ***18.8*** | ***19.8*** |
| C&S** | 13.1 | 13.4 | 13.6 | 13.9 | 14.5 | 14.1 | 11.7 | 10.4 | 9.7 | 8.5 | 8.6 |
| **Total** | **25.2** | **27.3** | **28.5** | **31.6** | **32.5** | **32.3** | **29.9** | **29.1** | **28.6** | **27.4** | **28.5** |
| **PG Alternative Scenario 1** | | | | | | | | | | | |
| Equipment Rebates* | 8.6 | 10.4 | 10.4 | 10.1 | 10.3 | 10.2 | 11.2 | 11.0 | 10.5 | 9.6 | 10.0 |
| BROs | 6.8 | 7.2 | 7.5 | 7.9 | 8.2 | 8.6 | 9.1 | 9.5 | 9.9 | 10.4 | 10.9 |
| ***Incentive Programs (Subtotal)*** | ***15.5*** | ***17.6*** | ***17.9*** | ***17.9*** | ***18.5*** | ***18.8*** | ***20.2*** | ***20.5*** | ***20.4*** | ***20.0*** | ***20.9*** |
| C&S** | 13.1 | 13.4 | 13.6 | 13.9 | 14.5 | 14.1 | 11.7 | 10.4 | 9.7 | 8.5 | 8.6 |
| **Total** | **28.6** | **31.1** | **31.5** | **31.9** | **33.0** | **32.9** | **31.9** | **30.9** | **30.1** | **28.6** | **29.5** |
| **PG Alternative Scenario 2** | | | | | | | | | | | |
| Equipment Rebates* | 4.0 | 5.4 | 5.4 | 5.7 | 5.9 | 6.5 | 6.5 | 6.7 | 8.4 | 8.1 | 8.6 |
| BROs | 6.8 | 7.2 | 7.5 | 7.9 | 8.2 | 8.6 | 9.1 | 9.5 | 9.9 | 10.4 | 10.9 |
| ***Incentive Programs (Subtotal)*** | ***10.8*** | ***12.6*** | ***13.0*** | ***13.6*** | ***14.1*** | ***15.1*** | ***15.6*** | ***16.2*** | ***18.3*** | ***18.5*** | ***19.6*** |
| C&S** | 13.1 | 13.4 | 13.6 | 13.9 | 14.5 | 14.1 | 11.7 | 10.4 | 9.7 | 8.5 | 8.6 |
| **Total** | **23.9** | **26.1** | **26.6** | **27.5** | **28.6** | **29.2** | **27.3** | **26.7** | **28.0** | **27.1** | **28.2** |
| **PG Alternative Scenario 3** | | | | | | | | | | | |
| Equipment Rebates* | 5.3 | 6.8 | 7.5 | 9.8 | 9.9 | 9.6 | 9.2 | 9.2 | 9.0 | 8.5 | 9.0 |
| BROs | 8.2 | 8.7 | 9.3 | 9.9 | 10.7 | 11.8 | 12.8 | 14.1 | 15.7 | 17.5 | 19.7 |
| ***Incentive Programs (Subtotal)*** | ***13.5*** | ***15.5*** | ***16.8*** | ***19.8*** | ***20.6*** | ***21.4*** | ***22.0*** | ***23.3*** | ***24.7*** | ***26.0*** | ***28.7*** |
| C&S** | 13.1 | 13.4 | 13.6 | 13.9 | 14.5 | 14.1 | 11.7 | 10.4 | 9.7 | 8.5 | 8.6 |
| **Total** | **26.6** | **28.9** | **30.4** | **33.7** | **35.1** | **35.5** | **33.7** | **33.7** | **34.4** | **34.5** | **37.3** |
| **PG Alternative Scenario 4** | | | | | | | | | | | |
| Equipment Rebates* | 9.0 | 10.7 | 10.7 | 10.3 | 10.4 | 10.3 | 11.2 | 11.1 | 10.6 | 9.7 | 10.1 |
| BROs | 8.2 | 8.7 | 9.3 | 9.9 | 10.7 | 11.8 | 12.8 | 14.1 | 15.7 | 17.5 | 19.7 |
| ***Incentive Programs (Subtotal)*** | ***17.2*** | ***19.4*** | ***20.0*** | ***20.2*** | ***21.1*** | ***22.1*** | ***24.1*** | ***25.2*** | ***26.3*** | ***27.2*** | ***29.8*** |
| C&S** | 13.1 | 13.4 | 13.6 | 13.9 | 14.5 | 14.1 | 11.7 | 10.4 | 9.7 | 8.5 | 8.6 |
| **Total** | **30.3** | **32.9** | **33.6** | **34.1** | **35.6** | **36.2** | **35.7** | **35.6** | **36.0** | **35.8** | **38.4** |
| **Low Income Programs** | | | | | | | | | | | |
| **PG Reference Scenario** | 0.74 | 0.76 | 0.75 | 0.70 | 0.69 | 0.67 | 0.66 | 0.64 | 0.60 | 0.59 | 0.58 |
| **PG Alternative Scenario 1** | 0.74 | 0.76 | 0.75 | 0.70 | 0.69 | 0.67 | 0.66 | 0.64 | 0.60 | 0.59 | 0.58 |
| **PG Alternative Scenario 2** | 0.74 | 0.76 | 0.75 | 0.70 | 0.69 | 0.67 | 0.66 | 0.64 | 0.60 | 0.59 | 0.58 |
| **PG Alternative Scenario 3** | 0.76 | 0.78 | 0.73 | 0.72 | 0.70 | 0.68 | 0.66 | 0.62 | 0.61 | 0.60 | 0.59 |
| **PG Alternative Scenario 4** | 0.76 | 0.78 | 0.73 | 0.72 | 0.70 | 0.68 | 0.66 | 0.62 | 0.61 | 0.60 | 0.59 |

*Excludes Low Income Programs

**Includes interactive effects

## H.2 SCE

Table H-4. SCE Electric Energy Savings (GWh/year)

| Year | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PG Reference Scenario** | | | | | | | | | | | |
| Equipment Rebates* | 160 | 186 | 190 | 181 | 180 | 176 | 161 | 153 | 147 | 130 | 129 |
| BROs | 150 | 166 | 178 | 191 | 204 | 217 | 231 | 246 | 262 | 279 | 297 |
| ***Incentive Programs (Subtotal)*** | ***310*** | ***352*** | ***368*** | ***372*** | ***384*** | ***393*** | ***392*** | ***399*** | ***409*** | ***408*** | ***425*** |
| C&S** | 667 | 662 | 649 | 651 | 618 | 596 | 554 | 515 | 462 | 402 | 341 |
| **Total** | **977** | **1,014** | **1,017** | **1,022** | **1,001** | **989** | **946** | **914** | **871** | **810** | **767** |
| **PG Alternative Scenario 1** | | | | | | | | | | | |
| Equipment Rebates* | 177 | 212 | 213 | 202 | 198 | 195 | 180 | 174 | 165 | 143 | 140 |
| BROs | 150 | 166 | 178 | 191 | 204 | 217 | 231 | 246 | 262 | 279 | 297 |
| ***Incentive Programs (Subtotal)*** | ***327*** | ***378*** | ***391*** | ***392*** | ***402*** | ***413*** | ***411*** | ***420*** | ***427*** | ***422*** | ***437*** |
| C&S** | 667 | 662 | 649 | 651 | 618 | 596 | 554 | 515 | 462 | 402 | 341 |
| **Total** | **994** | **1,041** | **1,040** | **1,043** | **1,020** | **1,009** | **965** | **935** | **888** | **824** | **778** |
| **PG Alternative Scenario 2** | | | | | | | | | | | |
| Equipment Rebates* | 148 | 174 | 177 | 171 | 170 | 167 | 153 | 146 | 142 | 126 | 125 |
| BROs | 150 | 166 | 178 | 191 | 204 | 217 | 231 | 246 | 262 | 279 | 297 |
| ***Incentive Programs (Subtotal)*** | ***299*** | ***341*** | ***355*** | ***362*** | ***374*** | ***384*** | ***385*** | ***393*** | ***404*** | ***405*** | ***422*** |
| C&S** | 667 | 662 | 649 | 651 | 618 | 596 | 554 | 515 | 462 | 402 | 341 |
| **Total** | **965** | **1,003** | **1,004** | **1,012** | **992** | **980** | **939** | **907** | **865** | **806** | **763** |
| **PG Alternative Scenario 3** | | | | | | | | | | | |
| Equipment Rebates* | 165 | 191 | 194 | 183 | 180 | 175 | 160 | 152 | 147 | 130 | 130 |
| BROs | 200 | 228 | 252 | 278 | 319 | 349 | 375 | 406 | 444 | 488 | 541 |
| ***Incentive Programs (Subtotal)*** | ***364*** | ***419*** | ***446*** | ***461*** | ***500*** | ***524*** | ***535*** | ***558*** | ***591*** | ***618*** | ***671*** |
| C&S** | 667 | 662 | 649 | 651 | 618 | 596 | 554 | 515 | 462 | 402 | 341 |
| **Total** | **1,031** | **1,081** | **1,094** | **1,111** | **1,118** | **1,120** | **1,089** | **1,073** | **1,052** | **1,019** | **1,012** |
| **PG Alternative Scenario 4** | | | | | | | | | | | |
| Equipment Rebates* | 188 | 224 | 224 | 209 | 204 | 198 | 181 | 175 | 166 | 145 | 143 |
| BROs | 200 | 228 | 252 | 278 | 319 | 349 | 375 | 406 | 444 | 488 | 541 |
| ***Incentive Programs (Subtotal)*** | ***388*** | ***452*** | ***476*** | ***487*** | ***523*** | ***547*** | ***556*** | ***581*** | ***610*** | ***633*** | ***684*** |
| C&S** | 667 | 662 | 649 | 651 | 618 | 596 | 554 | 515 | 462 | 402 | 341 |
| **Total** | **1,054** | **1,114** | **1,124** | **1,137** | **1,141** | **1,143** | **1,110** | **1,096** | **1,072** | **1,034** | **1,026** |
| **Low Income Programs** | | | | | | | | | | | |
| **PG Reference Scenario** | 7.26 | 8.04 | 7.94 | 8.25 | 8.57 | 8.86 | 9.15 | 9.35 | 9.60 | 9.72 | 9.46 |
| **PG Alternative Scenario 1** | 7.26 | 8.04 | 7.94 | 8.25 | 8.57 | 8.86 | 9.15 | 9.35 | 9.60 | 9.72 | 9.46 |
| **PG Alternative Scenario 2** | 7.26 | 8.04 | 7.94 | 8.25 | 8.57 | 8.86 | 9.15 | 9.35 | 9.60 | 9.72 | 9.46 |
| **PG Alternative Scenario 3** | 7.46 | 8.29 | 8.22 | 8.57 | 8.92 | 9.25 | 9.56 | 9.78 | 9.89 | 9.73 | 9.47 |
| **PG Alternative Scenario 4** | 7.46 | 8.29 | 8.22 | 8.57 | 8.92 | 9.25 | 9.56 | 9.78 | 9.89 | 9.73 | 9.47 |

*Excludes Low Income Programs
**Includes interactive effects

**Table H-5. SCE Demand Savings (MW)**

| Year | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PG Reference Scenario** | | | | | | | | | | | |
| Equipment Rebates* | 34.4 | 41.1 | 40.4 | 38.2 | 38.6 | 38.5 | 36.8 | 36.1 | 35.7 | 33.2 | 33.0 |
| BROs | 28.0 | 30.9 | 33.1 | 35.4 | 37.8 | 40.3 | 42.9 | 45.5 | 48.5 | 51.5 | 54.8 |
| ***Incentive Programs (Subtotal)*** | ***62.4*** | ***72.0*** | ***73.5*** | ***73.7*** | ***76.4*** | ***78.8*** | ***79.6*** | ***81.7*** | ***84.2*** | ***84.7*** | ***87.8*** |
| C&S** | 130.7 | 134.7 | 133.0 | 138.1 | 132.6 | 128.2 | 120.4 | 113.0 | 102.2 | 93.2 | 83.9 |
| **Total** | **193.1** | **206.7** | **206.5** | **211.7** | **209.0** | **207.0** | **200.0** | **194.7** | **186.4** | **177.9** | **171.7** |
| **PG Alternative Scenario 1** | | | | | | | | | | | |
| Equipment Rebates* | 40.4 | 51.3 | 50.6 | 47.6 | 47.2 | 47.5 | 45.5 | 44.5 | 43.2 | 39.7 | 38.8 |
| BROs | 28.0 | 30.9 | 33.1 | 35.4 | 37.8 | 40.3 | 42.9 | 45.5 | 48.5 | 51.5 | 54.8 |
| ***Incentive Programs (Subtotal)*** | ***68.5*** | ***82.1*** | ***83.7*** | ***83.0*** | ***85.0*** | ***87.9*** | ***88.3*** | ***90.0*** | ***91.7*** | ***91.2*** | ***93.6*** |
| C&S** | 130.7 | 134.7 | 133.0 | 138.1 | 132.6 | 128.2 | 120.4 | 113.0 | 102.2 | 93.2 | 83.9 |
| **Total** | **199.1** | **216.9** | **216.7** | **221.1** | **217.6** | **216.0** | **208.7** | **203.0** | **193.9** | **184.4** | **177.4** |
| **PG Alternative Scenario 2** | | | | | | | | | | | |
| Equipment Rebates* | 31.5 | 37.9 | 37.6 | 36.0 | 36.1 | 36.1 | 34.9 | 34.5 | 34.5 | 32.3 | 32.2 |
| BROs | 28.0 | 30.9 | 33.1 | 35.4 | 37.8 | 40.3 | 42.9 | 45.5 | 48.5 | 51.5 | 54.8 |
| ***Incentive Programs (Subtotal)*** | ***59.5*** | ***68.8*** | ***70.7*** | ***71.4*** | ***73.9*** | ***76.4*** | ***77.8*** | ***80.0*** | ***82.9*** | ***83.8*** | ***86.9*** |
| C&S** | 130.7 | 134.7 | 133.0 | 138.1 | 132.6 | 128.2 | 120.4 | 113.0 | 102.2 | 93.2 | 83.9 |
| **Total** | **190.2** | **203.5** | **203.7** | **209.5** | **206.5** | **204.6** | **198.2** | **193.0** | **185.1** | **177.0** | **170.8** |
| **PG Alternative Scenario 3** | | | | | | | | | | | |
| Equipment Rebates* | 35.0 | 41.8 | 41.0 | 38.7 | 38.9 | 38.8 | 37.1 | 36.4 | 36.0 | 33.5 | 33.4 |
| BROs | 36.2 | 41.3 | 45.8 | 50.4 | 56.9 | 62.2 | 66.9 | 72.4 | 79.1 | 86.9 | 96.3 |
| ***Incentive Programs (Subtotal)*** | ***71.2*** | ***83.1*** | ***86.8*** | ***89.1*** | ***95.8*** | ***101.0*** | ***104.0*** | ***108.8*** | ***115.1*** | ***120.4*** | ***129.7*** |
| C&S** | 130.7 | 134.7 | 133.0 | 138.1 | 132.6 | 128.2 | 120.4 | 113.0 | 102.2 | 93.2 | 83.9 |
| **Total** | **201.9** | **217.8** | **219.8** | **227.2** | **228.4** | **229.1** | **224.3** | **221.8** | **217.3** | **213.6** | **213.5** |
| **PG Alternative Scenario 4** | | | | | | | | | | | |
| Equipment Rebates* | 42.6 | 53.9 | 52.9 | 49.6 | 49.0 | 49.2 | 46.9 | 45.8 | 44.4 | 40.6 | 39.7 |
| BROs | 36.2 | 41.3 | 45.8 | 50.4 | 56.9 | 62.2 | 66.9 | 72.4 | 79.1 | 86.9 | 96.3 |
| ***Incentive Programs (Subtotal)*** | ***78.7*** | ***95.2*** | ***98.7*** | ***100.0*** | ***105.8*** | ***111.4*** | ***113.8*** | ***118.2*** | ***123.5*** | ***127.5*** | ***136.0*** |
| C&S** | 130.7 | 134.7 | 133.0 | 138.1 | 132.6 | 128.2 | 120.4 | 113.0 | 102.2 | 93.2 | 83.9 |
| **Total** | **209.4** | **229.9** | **231.7** | **238.0** | **238.5** | **239.6** | **234.2** | **231.2** | **225.7** | **220.7** | **219.9** |
| **Low Income Programs** | | | | | | | | | | | |
| **PG Reference Scenario** | 7.31 | 8.07 | 7.67 | 7.73 | 7.81 | 7.90 | 8.01 | 8.08 | 8.20 | 8.23 | 8.00 |
| **PG Alternative Scenario 1** | 7.31 | 8.07 | 7.67 | 7.73 | 7.81 | 7.90 | 8.01 | 8.08 | 8.20 | 8.23 | 8.00 |
| **PG Alternative Scenario 2** | 7.31 | 8.07 | 7.67 | 7.73 | 7.81 | 7.90 | 8.01 | 8.08 | 8.20 | 8.23 | 8.00 |
| **PG Alternative Scenario 3** | 7.59 | 8.40 | 8.01 | 8.08 | 8.17 | 8.28 | 8.40 | 8.48 | 8.50 | 8.33 | 8.10 |
| **PG Alternative Scenario 4** | 7.59 | 8.40 | 8.01 | 8.08 | 8.17 | 8.28 | 8.40 | 8.48 | 8.50 | 8.33 | 8.10 |

*Excludes Low Income Programs
**Includes interactive effects

## H.3 SCG

**Table H-6. SCG Gas Savings (MMtherm/year)**

| Year | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PG Reference Scenario** | | | | | | | | | | | |
| Equipment Rebates* | 5.3 | 6.2 | 8.6 | 8.3 | 7.8 | 7.8 | 7.3 | 6.9 | 6.6 | 6.6 | 7.5 |
| BROs | 7.9 | 8.1 | 8.4 | 8.6 | 8.9 | 9.2 | 9.5 | 9.9 | 10.3 | 10.7 | 11.2 |
| ***Incentive Programs (Subtotal)*** | ***13.1*** | ***14.4*** | ***16.9*** | ***16.9*** | ***16.7*** | ***17.1*** | ***16.9*** | ***16.8*** | ***16.9*** | ***17.3*** | ***18.7*** |
| C&S** | 21.0 | 21.5 | 21.7 | 22.3 | 23.2 | 22.6 | 18.7 | 16.7 | 15.5 | 13.7 | 13.8 |
| **Total** | **34.1** | **35.9** | **38.7** | **39.2** | **39.9** | **39.6** | **35.6** | **33.6** | **32.4** | **31.0** | **32.4** |
| **PG Alternative Scenario 1** | | | | | | | | | | | |
| Equipment Rebates* | 8.9 | 9.2 | 9.1 | 8.8 | 8.3 | 10.0 | 9.2 | 8.5 | 9.3 | 8.7 | 8.9 |
| BROs | 7.9 | 8.1 | 8.4 | 8.6 | 8.9 | 9.2 | 9.5 | 9.9 | 10.3 | 10.7 | 11.2 |
| ***Incentive Programs (Subtotal)*** | ***16.8*** | ***17.3*** | ***17.5*** | ***17.4*** | ***17.2*** | ***19.2*** | ***18.8*** | ***18.4*** | ***19.6*** | ***19.4*** | ***20.1*** |
| C&S** | 21.0 | 21.5 | 21.7 | 22.3 | 23.2 | 22.6 | 18.7 | 16.7 | 15.5 | 13.7 | 13.8 |
| **Total** | **37.8** | **38.9** | **39.2** | **39.7** | **40.4** | **41.8** | **37.5** | **35.2** | **35.1** | **33.1** | **33.9** |
| **PG Alternative Scenario 2** | | | | | | | | | | | |
| Equipment Rebates* | 4.4 | 4.6 | 4.5 | 5.0 | 5.1 | 5.1 | 6.8 | 6.4 | 6.1 | 6.1 | 6.5 |
| BROs | 7.9 | 8.1 | 8.4 | 8.6 | 8.9 | 9.2 | 9.5 | 9.9 | 10.3 | 10.7 | 11.2 |
| ***Incentive Programs (Subtotal)*** | ***12.3*** | ***12.7*** | ***12.9*** | ***13.6*** | ***14.0*** | ***14.3*** | ***16.3*** | ***16.3*** | ***16.4*** | ***16.8*** | ***17.7*** |
| C&S** | 21.0 | 21.5 | 21.7 | 22.3 | 23.2 | 22.6 | 18.7 | 16.7 | 15.5 | 13.7 | 13.8 |
| **Total** | **33.2** | **34.2** | **34.6** | **35.9** | **37.2** | **36.8** | **35.0** | **33.0** | **31.9** | **30.5** | **31.5** |
| **PG Alternative Scenario 3** | | | | | | | | | | | |
| Equipment Rebates* | 5.3 | 6.3 | 8.6 | 8.3 | 7.8 | 7.8 | 7.3 | 6.9 | 6.5 | 6.5 | 7.4 |
| BROs | 8.7 | 9.4 | 9.9 | 10.5 | 11.4 | 12.2 | 13.1 | 14.2 | 15.5 | 17.1 | 19.0 |
| ***Incentive Programs (Subtotal)*** | ***14.1*** | ***15.7*** | ***18.6*** | ***18.8*** | ***19.1*** | ***20.0*** | ***20.3*** | ***21.1*** | ***22.0*** | ***23.6*** | ***26.4*** |
| C&S** | 21.0 | 21.5 | 21.7 | 22.3 | 23.2 | 22.6 | 18.7 | 16.7 | 15.5 | 13.7 | 13.8 |
| **Total** | **35.0** | **37.2** | **40.3** | **41.1** | **42.3** | **42.5** | **39.1** | **37.8** | **37.6** | **37.3** | **40.1** |
| **PG Alternative Scenario 4** | | | | | | | | | | | |
| Equipment Rebates* | 9.5 | 9.8 | 9.6 | 9.2 | 8.6 | 10.3 | 9.3 | 8.6 | 9.3 | 8.6 | 8.8 |
| BROs | 8.7 | 9.4 | 9.9 | 10.5 | 11.4 | 12.2 | 13.1 | 14.2 | 15.5 | 17.1 | 19.0 |
| ***Incentive Programs (Subtotal)*** | ***18.3*** | ***19.2*** | ***19.5*** | ***19.7*** | ***20.0*** | ***22.4*** | ***22.4*** | ***22.7*** | ***24.8*** | ***25.7*** | ***27.7*** |
| C&S** | 21.0 | 21.5 | 21.7 | 22.3 | 23.2 | 22.6 | 18.7 | 16.7 | 15.5 | 13.7 | 13.8 |
| **Total** | **39.2** | **40.7** | **41.2** | **42.0** | **43.2** | **45.0** | **41.1** | **39.5** | **40.3** | **39.4** | **41.5** |
| **Low Income Programs** | | | | | | | | | | | |
| **PG Reference Scenario** | 1.40 | 1.40 | 1.02 | 1.02 | 1.03 | 1.02 | 1.00 | 0.98 | 0.97 | 0.95 | 0.93 |
| **PG Alternative Scenario 1** | 1.40 | 1.40 | 1.02 | 1.02 | 1.03 | 1.02 | 1.00 | 0.98 | 0.97 | 0.95 | 0.93 |
| **PG Alternative Scenario 2** | 1.40 | 1.40 | 1.02 | 1.02 | 1.03 | 1.02 | 1.00 | 0.98 | 0.97 | 0.95 | 0.93 |
| **PG Alternative Scenario 3** | 1.44 | 1.43 | 1.05 | 1.05 | 1.05 | 1.04 | 1.03 | 1.00 | 0.99 | 0.97 | 0.95 |
| **PG Alternative Scenario 4** | 1.44 | 1.43 | 1.05 | 1.05 | 1.05 | 1.04 | 1.03 | 1.00 | 0.99 | 0.97 | 0.95 |

*Excludes Low Income Programs

**Includes interactive effects

## H.4 SDG&E

Table H-7. SDG&E Electric Energy Savings (GWh/year)

| Year | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PG Reference Scenario** | | | | | | | | | | | |
| Equipment Rebates* | 25.7 | 31.7 | 31.6 | 32.1 | 32.0 | 31.5 | 29.3 | 28.7 | 28.5 | 27.4 | 27.3 |
| BROs | 52.9 | 58.0 | 61.1 | 64.1 | 67.3 | 70.8 | 74.3 | 78.0 | 82.1 | 86.5 | 91.3 |
| ***Incentive Programs (Subtotal)*** | ***78.6*** | ***89.7*** | ***92.6*** | ***96.2*** | ***99.4*** | ***102.3*** | ***103.7*** | ***106.7*** | ***110.6*** | ***113.9*** | ***118.6*** |
| C&S** | 151.3 | 150.3 | 147.2 | 147.6 | 140.2 | 135.2 | 125.8 | 116.8 | 104.7 | 91.2 | 77.5 |
| **Total** | **229.9** | **240.0** | **239.8** | **243.8** | **239.6** | **237.5** | **229.4** | **223.5** | **215.4** | **205.1** | **196.1** |
| **PG Alternative Scenario 1** | | | | | | | | | | | |
| Equipment Rebates* | 30.9 | 37.9 | 38.1 | 36.8 | 36.5 | 35.9 | 32.9 | 32.1 | 31.7 | 28.1 | 28.6 |
| BROs | 52.9 | 58.0 | 61.1 | 64.1 | 67.3 | 70.8 | 74.3 | 78.0 | 82.1 | 86.5 | 91.3 |
| ***Incentive Programs (Subtotal)*** | ***83.8*** | ***95.9*** | ***99.1*** | ***100.8*** | ***103.9*** | ***106.7*** | ***107.2*** | ***110.1*** | ***113.8*** | ***114.6*** | ***120.0*** |
| C&S** | 151.3 | 150.3 | 147.2 | 147.6 | 140.2 | 135.2 | 125.8 | 116.8 | 104.7 | 91.2 | 77.5 |
| **Total** | **235.1** | **246.2** | **246.3** | **248.5** | **244.1** | **241.9** | **232.9** | **226.9** | **218.5** | **205.8** | **197.4** |
| **PG Alternative Scenario 2** | | | | | | | | | | | |
| Equipment Rebates* | 19.8 | 25.5 | 25.5 | 25.4 | 26.1 | 25.5 | 23.8 | 23.3 | 23.4 | 21.6 | 22.1 |
| BROs | 52.9 | 58.0 | 61.1 | 64.1 | 67.3 | 70.8 | 74.3 | 78.0 | 82.1 | 86.5 | 91.3 |
| ***Incentive Programs (Subtotal)*** | ***72.7*** | ***83.4*** | ***86.6*** | ***89.5*** | ***93.4*** | ***96.3*** | ***98.1*** | ***101.3*** | ***105.5*** | ***108.1*** | ***113.4*** |
| C&S** | 151.3 | 150.3 | 147.2 | 147.6 | 140.2 | 135.2 | 125.8 | 116.8 | 104.7 | 91.2 | 77.5 |
| **Total** | **224.0** | **233.7** | **233.8** | **237.1** | **233.6** | **231.5** | **223.9** | **218.2** | **210.3** | **199.3** | **190.9** |
| **PG Alternative Scenario 3** | | | | | | | | | | | |
| Equipment Rebates* | 26.4 | 32.4 | 32.1 | 32.5 | 32.3 | 31.7 | 29.6 | 29.1 | 28.9 | 27.9 | 27.8 |
| BROs | 62.4 | 67.0 | 73.8 | 80.0 | 91.6 | 100.2 | 110.0 | 121.3 | 135.0 | 151.3 | 170.9 |
| ***Incentive Programs (Subtotal)*** | ***88.8*** | ***99.4*** | ***105.9*** | ***112.5*** | ***123.9*** | ***131.9*** | ***139.5*** | ***150.4*** | ***163.9*** | ***179.1*** | ***198.6*** |
| C&S** | 151.3 | 150.3 | 147.2 | 147.6 | 140.2 | 135.2 | 125.8 | 116.8 | 104.7 | 91.2 | 77.5 |
| **Total** | **240.1** | **249.7** | **253.1** | **260.1** | **264.2** | **267.1** | **265.3** | **267.2** | **268.7** | **270.3** | **276.1** |
| **PG Alternative Scenario 4** | | | | | | | | | | | |
| Equipment Rebates* | 32.5 | 39.8 | 39.7 | 38.1 | 37.8 | 37.1 | 33.9 | 33.3 | 33.0 | 29.3 | 29.8 |
| BROs | 62.4 | 67.0 | 73.8 | 80.0 | 91.6 | 100.2 | 110.0 | 121.3 | 135.0 | 151.3 | 170.9 |
| ***Incentive Programs (Subtotal)*** | ***94.9*** | ***106.8*** | ***113.5*** | ***118.2*** | ***129.4*** | ***137.3*** | ***143.9*** | ***154.6*** | ***168.0*** | ***180.5*** | ***200.7*** |
| C&S** | 151.3 | 150.3 | 147.2 | 147.6 | 140.2 | 135.2 | 125.8 | 116.8 | 104.7 | 91.2 | 77.5 |
| **Total** | **246.2** | **257.1** | **260.7** | **265.8** | **269.6** | **272.5** | **269.6** | **271.4** | **272.8** | **271.7** | **278.1** |
| **Low Income Programs** | | | | | | | | | | | |
| **PG Reference Scenario** | 1.13 | 1.25 | 1.29 | 1.34 | 1.40 | 1.41 | 1.43 | 1.44 | 1.43 | 1.39 | 1.36 |
| **PG Alternative Scenario 1** | 1.13 | 1.25 | 1.29 | 1.34 | 1.40 | 1.41 | 1.43 | 1.44 | 1.43 | 1.39 | 1.36 |
| **PG Alternative Scenario 2** | 1.13 | 1.25 | 1.29 | 1.34 | 1.40 | 1.41 | 1.43 | 1.44 | 1.43 | 1.39 | 1.36 |
| **PG Alternative Scenario 3** | 1.16 | 1.29 | 1.34 | 1.40 | 1.45 | 1.47 | 1.49 | 1.48 | 1.47 | 1.41 | 1.38 |
| **PG Alternative Scenario 4** | 1.16 | 1.29 | 1.34 | 1.40 | 1.45 | 1.47 | 1.49 | 1.48 | 1.47 | 1.41 | 1.38 |

*Excludes Low Income Programs

**Includes interactive effects

### Table H-8. SDG&E Demand Savings (MW)

| Year | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PG Reference Scenario** | | | | | | | | | | | |
| Equipment Rebates* | 5.4 | 6.7 | 6.5 | 6.6 | 6.7 | 6.7 | 6.5 | 6.4 | 6.3 | 6.1 | 6.2 |
| BROs | 9.8 | 10.5 | 11.0 | 11.5 | 12.1 | 12.7 | 13.2 | 13.9 | 14.5 | 15.3 | 16.1 |
| ***Incentive Programs (Subtotal)*** | ***15.2*** | ***17.1*** | ***17.5*** | ***18.2*** | ***18.8*** | ***19.4*** | ***19.7*** | ***20.2*** | ***20.9*** | ***21.4*** | ***22.2*** |
| C&S** | 30.6 | 31.3 | 31.0 | 32.0 | 30.7 | 29.7 | 28.0 | 26.3 | 23.8 | 21.8 | 19.6 |
| **Total** | **45.8** | **48.5** | **48.5** | **50.1** | **49.5** | **49.1** | **47.7** | **46.5** | **44.7** | **43.2** | **41.9** |
| **PG Alternative Scenario 1** | | | | | | | | | | | |
| Equipment Rebates* | 6.3 | 7.8 | 7.8 | 7.6 | 7.7 | 7.6 | 7.2 | 7.1 | 7.0 | 6.4 | 6.5 |
| BROs | 9.8 | 10.5 | 11.0 | 11.5 | 12.1 | 12.7 | 13.2 | 13.9 | 14.5 | 15.3 | 16.1 |
| ***Incentive Programs (Subtotal)*** | ***16.1*** | ***18.3*** | ***18.8*** | ***19.1*** | ***19.8*** | ***20.3*** | ***20.4*** | ***20.9*** | ***21.6*** | ***21.6*** | ***22.5*** |
| C&S** | 30.6 | 31.3 | 31.0 | 32.0 | 30.7 | 29.7 | 28.0 | 26.3 | 23.8 | 21.8 | 19.6 |
| **Total** | **46.7** | **49.6** | **49.7** | **51.1** | **50.5** | **50.0** | **48.4** | **47.2** | **45.4** | **43.4** | **42.2** |
| **PG Alternative Scenario 2** | | | | | | | | | | | |
| Equipment Rebates* | 4.2 | 5.3 | 5.2 | 5.3 | 5.4 | 5.4 | 5.2 | 5.1 | 5.1 | 4.8 | 4.9 |
| BROs | 9.8 | 10.5 | 11.0 | 11.5 | 12.1 | 12.7 | 13.2 | 13.9 | 14.5 | 15.3 | 16.1 |
| ***Incentive Programs (Subtotal)*** | ***14.0*** | ***15.8*** | ***16.2*** | ***16.8*** | ***17.5*** | ***18.0*** | ***18.4*** | ***19.0*** | ***19.7*** | ***20.1*** | ***21.0*** |
| C&S** | 30.6 | 31.3 | 31.0 | 32.0 | 30.7 | 29.7 | 28.0 | 26.3 | 23.8 | 21.8 | 19.6 |
| **Total** | **44.6** | **47.1** | **47.2** | **48.7** | **48.2** | **47.8** | **46.4** | **45.3** | **43.5** | **41.8** | **40.6** |
| **PG Alternative Scenario 3** | | | | | | | | | | | |
| Equipment Rebates* | 5.5 | 6.8 | 6.6 | 6.7 | 6.8 | 6.8 | 6.5 | 6.5 | 6.4 | 6.2 | 6.3 |
| BROs | 10.9 | 11.7 | 12.9 | 13.9 | 15.5 | 16.8 | 18.3 | 20.1 | 22.2 | 24.6 | 27.5 |
| ***Incentive Programs (Subtotal)*** | ***16.4*** | ***18.4*** | ***19.5*** | ***20.6*** | ***22.3*** | ***23.6*** | ***24.9*** | ***26.5*** | ***28.6*** | ***30.8*** | ***33.8*** |
| C&S** | 30.6 | 31.3 | 31.0 | 32.0 | 30.7 | 29.7 | 28.0 | 26.3 | 23.8 | 21.8 | 19.6 |
| **Total** | **47.0** | **49.8** | **50.4** | **52.6** | **53.0** | **53.4** | **52.9** | **52.8** | **52.4** | **52.6** | **53.4** |
| **PG Alternative Scenario 4** | | | | | | | | | | | |
| Equipment Rebates* | 6.5 | 8.0 | 8.0 | 7.8 | 7.9 | 7.8 | 7.4 | 7.3 | 7.2 | 6.5 | 6.7 |
| BROs | 10.9 | 11.7 | 12.9 | 13.9 | 15.5 | 16.8 | 18.3 | 20.1 | 22.2 | 24.6 | 27.5 |
| ***Incentive Programs (Subtotal)*** | ***17.4*** | ***19.7*** | ***20.9*** | ***21.7*** | ***23.4*** | ***24.6*** | ***25.7*** | ***27.3*** | ***29.4*** | ***31.1*** | ***34.2*** |
| C&S** | 30.6 | 31.3 | 31.0 | 32.0 | 30.7 | 29.7 | 28.0 | 26.3 | 23.8 | 21.8 | 19.6 |
| **Total** | **48.0** | **51.1** | **51.8** | **53.7** | **54.1** | **54.4** | **53.7** | **53.6** | **53.2** | **52.9** | **53.8** |
| **Low Income Programs** | | | | | | | | | | | |
| **PG Reference Scenario** | 1.64 | 1.83 | 1.81 | 1.81 | 1.82 | 1.80 | 1.79 | 1.78 | 1.77 | 1.72 | 1.68 |
| **PG Alternative Scenario 1** | 1.64 | 1.83 | 1.81 | 1.81 | 1.82 | 1.80 | 1.79 | 1.78 | 1.77 | 1.72 | 1.68 |
| **PG Alternative Scenario 2** | 1.64 | 1.83 | 1.81 | 1.81 | 1.82 | 1.80 | 1.79 | 1.78 | 1.77 | 1.72 | 1.68 |
| **PG Alternative Scenario 3** | 1.71 | 1.90 | 1.89 | 1.89 | 1.90 | 1.89 | 1.87 | 1.86 | 1.84 | 1.76 | 1.72 |
| **PG Alternative Scenario 4** | 1.71 | 1.90 | 1.89 | 1.89 | 1.90 | 1.89 | 1.87 | 1.86 | 1.84 | 1.76 | 1.72 |

*Excludes Low Income Programs
**Includes interactive effects

 

Table H-9. SDG&E Gas Energy Savings (MMtherm/year)

| Year | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PG Reference Scenario** | | | | | | | | | | | |
| Equipment Rebates* | 0.56 | 0.71 | 0.73 | 0.73 | 0.74 | 0.77 | 0.74 | 0.73 | 0.71 | 0.65 | 0.64 |
| BROs | 1.41 | 1.45 | 1.50 | 1.55 | 1.60 | 1.66 | 1.74 | 1.82 | 1.91 | 2.00 | 2.11 |
| ***Incentive Programs (Subtotal)*** | ***1.98*** | ***2.16*** | ***2.23*** | ***2.27*** | ***2.34*** | ***2.43*** | ***2.48*** | ***2.54*** | ***2.62*** | ***2.65*** | ***2.75*** |
| C&S** | 1.49 | 1.53 | 1.54 | 1.58 | 1.65 | 1.60 | 1.33 | 1.19 | 1.10 | 0.97 | 0.98 |
| **Total** | **3.46** | **3.69** | **3.77** | **3.86** | **3.99** | **4.03** | **3.80** | **3.73** | **3.72** | **3.62** | **3.73** |
| **PG Alternative Scenario 1** | | | | | | | | | | | |
| Equipment Rebates* | 0.62 | 0.78 | 0.78 | 0.76 | 0.78 | 0.81 | 0.78 | 0.77 | 0.83 | 0.77 | 0.78 |
| BROs | 1.41 | 1.45 | 1.50 | 1.55 | 1.60 | 1.66 | 1.74 | 1.82 | 1.91 | 2.00 | 2.11 |
| ***Incentive Programs (Subtotal)*** | ***2.04*** | ***2.24*** | ***2.28*** | ***2.31*** | ***2.38*** | ***2.48*** | ***2.51*** | ***2.58*** | ***2.74*** | ***2.78*** | ***2.89*** |
| C&S** | 1.49 | 1.53 | 1.54 | 1.58 | 1.65 | 1.60 | 1.33 | 1.19 | 1.10 | 0.97 | 0.98 |
| **Total** | **3.52** | **3.77** | **3.82** | **3.89** | **4.03** | **4.08** | **3.84** | **3.77** | **3.84** | **3.75** | **3.87** |
| **PG Alternative Scenario 2** | | | | | | | | | | | |
| Equipment Rebates* | 0.49 | 0.63 | 0.65 | 0.67 | 0.69 | 0.70 | 0.69 | 0.68 | 0.66 | 0.60 | 0.61 |
| BROs | 1.41 | 1.45 | 1.50 | 1.55 | 1.60 | 1.66 | 1.74 | 1.82 | 1.91 | 2.00 | 2.11 |
| ***Incentive Programs (Subtotal)*** | ***1.90*** | ***2.09*** | ***2.15*** | ***2.22*** | ***2.30*** | ***2.36*** | ***2.43*** | ***2.49*** | ***2.56*** | ***2.60*** | ***2.72*** |
| C&S** | 1.49 | 1.53 | 1.54 | 1.58 | 1.65 | 1.60 | 1.33 | 1.19 | 1.10 | 0.97 | 0.98 |
| **Total** | **3.39** | **3.62** | **3.69** | **3.81** | **3.94** | **3.97** | **3.76** | **3.68** | **3.67** | **3.57** | **3.69** |
| **PG Alternative Scenario 3** | | | | | | | | | | | |
| Equipment Rebates* | 0.57 | 0.72 | 0.74 | 0.73 | 0.75 | 0.78 | 0.75 | 0.73 | 0.72 | 0.65 | 0.65 |
| BROs | 1.53 | 1.62 | 1.75 | 1.88 | 2.07 | 2.26 | 2.50 | 2.78 | 3.13 | 3.55 | 4.06 |
| ***Incentive Programs (Subtotal)*** | ***2.10*** | ***2.34*** | ***2.49*** | ***2.61*** | ***2.82*** | ***3.04*** | ***3.24*** | ***3.51*** | ***3.84*** | ***4.20*** | ***4.71*** |
| C&S** | 1.49 | 1.53 | 1.54 | 1.58 | 1.65 | 1.60 | 1.33 | 1.19 | 1.10 | 0.97 | 0.98 |
| **Total** | **3.59** | **3.86** | **4.03** | **4.20** | **4.47** | **4.64** | **4.57** | **4.70** | **4.95** | **5.17** | **5.69** |
| **PG Alternative Scenario 4** | | | | | | | | | | | |
| Equipment Rebates* | 0.65 | 0.82 | 0.81 | 0.79 | 0.81 | 0.84 | 0.80 | 0.79 | 0.85 | 0.79 | 0.80 |
| BROs | 1.53 | 1.62 | 1.75 | 1.88 | 2.07 | 2.26 | 2.50 | 2.78 | 3.13 | 3.55 | 4.06 |
| ***Incentive Programs (Subtotal)*** | ***2.18*** | ***2.44*** | ***2.56*** | ***2.67*** | ***2.88*** | ***3.11*** | ***3.30*** | ***3.57*** | ***3.98*** | ***4.34*** | ***4.86*** |
| C&S** | 1.49 | 1.53 | 1.54 | 1.58 | 1.65 | 1.60 | 1.33 | 1.19 | 1.10 | 0.97 | 0.98 |
| **Total** | **3.67** | **3.97** | **4.11** | **4.26** | **4.53** | **4.71** | **4.63** | **4.75** | **5.08** | **5.31** | **5.84** |
| **Low Income Programs** | | | | | | | | | | | |
| **PG Reference Scenario** | 0.19 | 0.19 | 0.19 | 0.18 | 0.18 | 0.18 | 0.17 | 0.17 | 0.15 | 0.15 | 0.14 |
| **PG Alternative Scenario 1** | 0.19 | 0.19 | 0.19 | 0.18 | 0.18 | 0.18 | 0.17 | 0.17 | 0.15 | 0.15 | 0.14 |
| **PG Alternative Scenario 2** | 0.19 | 0.19 | 0.19 | 0.18 | 0.18 | 0.18 | 0.17 | 0.17 | 0.15 | 0.15 | 0.14 |
| **PG Alternative Scenario 3** | 0.19 | 0.19 | 0.19 | 0.19 | 0.18 | 0.18 | 0.17 | 0.16 | 0.15 | 0.15 | 0.14 |
| **PG Alternative Scenario 4** | 0.19 | 0.19 | 0.19 | 0.19 | 0.18 | 0.18 | 0.17 | 0.16 | 0.15 | 0.15 | 0.14 |

*Excludes Low Income Programs
**Includes interactive effects

# APPENDIX I. RESPONSE TO COMMENTS

The following pages in this appendix summarizes stakeholder **technical** comments and the Navigant team's response. This section is not meant to include responses to policy-related comments or stakeholder recommendations on what scenario to adopt for goals as they are for CPUC staff to consider.

| Topic Area | Party | Summary of Issue | Navigant Response |
|---|---|---|---|
| ABAL | SCE | Current potential forecast does not account for the energy savings allocations from statewide energy efficiency programs. Load share-based allocation of statewide savings may result in more or fewer savings being attributed to SCE than it is assigned in the goal setting process. SCE requests that the Commission incorporate this topic as part of the discussion in the decision adopting goals for 2020 and future years, to improve clarity about the impacts of transitioning to the statewide administration model.<br><br>The review and approval process for the ABAL will require flexibility in the assumptions due to adopted goals, available measures, and timing of solicitations being completed across the state. | The PG study is bottom up forecast based on technologies and market status in each IOU territory. Allocation of statewide savings based on load is an accounting exercise, not a precise estimate of where saving occur. Future statewide implementers should consider tracking data to understand where savings are occurring and compare to the load-based allocation approach to inform future potential studies. |
| AIMS | PG&E | Review NTG and EUL assumptions for: Agriculture \| Low Pressure Irrigation, Industrial \| Motor VFD – Efficient, Industrial \| Fan VFD – Efficient, Industrial \| Pump VFD – Efficient | Changed AG low pressure irrigation to 0.47 NTG (http://www.calmac.org/publications/SprinklerReport_2015_final_report_appendices.pdf); VFD EUL is based on the remaining useful life of the host equipment which is 15 years, therefore, the EUL is 5 years per DEER Resolution E-4818 re-affirmed the long-standing policy that EUL values for add-on equipment measures are limited to the RUL values of the host equipment. |
| AIMS | CEDMC | While this may not be the venue to attempt to fix the lengthy and resource-intensive review process for custom AIMS projects, the results of the Potential and Goal Study should send a clear alarm, and trigger both examination and corrective action. Commission should require future consultants to highlight in the study the challenges existing policies are having on the industry and the identifiable market potential; and appropriately fund market research to better inform future studies. | Navigant added language in the report clarifying that the decreasing trend in custom projects are based on historical program participation trends and not necessarily related to the actual market potential.<br><br>We do agree that understanding the technical potential of the AIMS is critical for improving future forecasts. Additionally, we believe that revisiting industry standard practice assumptions and ex ante program requirements (such as preponderance of evidence, free ridership reviews and baseline adjustments) may provide insight in opening up more potential (i.e. program participation) to this segment. |
| AIMS | SCE | 2c. Reduce Whole Building savings for Ind and Ag. Reflect declining savings commensurate to the revised penetration rate applied to generic custom savings to show a 2.1% annual decrease (p. 63 draft study). | Whole Building also includes SEM and emerging tech. The custom savings is based on the decrease. In aggregate, the savings for whole building looks like it increases. |

| Topic Area | Party | Summary of Issue | Navigant Response |
|---|---|---|---|
| AIMS | NRDC | More Research is Required to Determine Industrial Sector Energy Savings Potential; Industrial Sector Potential Estimates Vary Significantly in Each Study Iteration. Although the industrial sector is responsible for approximately 30% of electricity consumption in IOU service territory in California,2 the potential study estimates programmatic market potential in the industrial sector to be only ~9% of total programmatic potential in 2020. This inconsistency deserves further scrutiny. Per NRDC's initial investigation, the savings potential in the industrial sector is particularly sensitive to assumption updates in each study iteration which are likely derived from recent programmatic accomplishments. This is illustrated by the significant differences in industrial sector market potential estimates from study to study; the average incremental net-energy savings market potential for the years 2020 through 2022 was 112 GWh in the 2015 Study, 159 GWh in the 2018 Study, and 72 GWh in the 2019 PG Study. NRDC was not able to find any specific reasons for these giant variations in energy savings potential estimates in any of Navigant's reports. Navigant's reports do not indicate a major change in methodology or data across these studies. Some decrease in market potential is expected due to programmatic achievements and evolving baselines, but this extreme pattern requires explanation. Navigant should, at minimum: (1) publish the analysis conducted to develop industrial sector savings estimates for stakeholder review; (2) be transparent regarding the certainty of these estimates; (3) conduct a review of how other jurisdictions determine potential for the industrial sector; and (4) provide recommendations on what data and resources are necessary to conduct an improved analysis. | According to the IEPR data, industrial sector is 15% of the electricity and 38% of the gas in the state. We are not at this time going to comment on the historical swings, however, it is important to note some significant edits this year: (A) Lighting drastically decreased (75%); (B) Assumptions of ISP taken into consideration regarding air compressors (50%); and (C) historical trend of showing a decrease in savings over the last two years.<br><br>Our methods are described in the report and shared in the AIMS webinar. The background analysis is based on proprietary tools Navigant has developed over the last 8 years for multiple projects and will not be released. We have observed the AIMS sectors are poorly characterized as there are very few comprehensive market studies in CA.<br><br>Regarding the review of other jurisdictions while this is not explicitly in scope of this study, Navigant has completed industrial potential analysis in other jurisdictions. In all cases, the savings estimates are lower than expected for several reasons: (A) there is no good baseline or saturation data for industry; (B) assumptions are made on costs; (C) all Navigant studies leverage the IAC database - to various levels. Our report will be updated to include some commentary on what future data should be collected help inform AIMS potential. |
| BROs | PG&E | The levelized costs (i.e., $/kWh) for BRO programs presented by Navigant seem extremely high compared to historical values. At the levelized costs presented by Navigant, it is unlikely that many of the interventions exceeding $0.20/kWh would be cost-effective because $0.20/kWh exceeds PG&E's TRC costs at the portfolio level and for all sectors. Navigant should reevaluate the potential for these programs based on cost-effectiveness criteria. | Costs for BROs programs are input as $/first year savings. They are not a lifetime levelized cost and therefore are not directly comparable to avoided costs. All programs that contain first year costs above $0.20/kWh have EULs greater than 1 year. |
| BROs | PG&E | PG&E respectfully disagrees with the assumptions used to forecast HERs energy savings in the Navigant Study. PG&E believes the Navigant Study overestimates the savings potential for the following four reasons. (See page 7-8 of PG&E formal comments for details) | We have modified our forecasted penetration growth rate to account for a diminished savings value in future HERs waves while maintaining our calibrated energy savings according to recent impact evaluations. |

| Topic Area | Party | Summary of Issue | Navigant Response |
|---|---|---|---|
| BROs | PG&E | Regarding the potential in the forecast for building benchmarking, PG&E respectfully disagrees with Navigant's assumptions for applicability given that the IOUs are disallowed to claim savings for benchmarking activities that are already required by law. 15 Many buildings in the population used in the Navigant Study already report benchmarking information to the California Energy Commission (CEC) through the State of California's Building Energy Use Benchmarking and Public Disclosure Program. The IOUs cannot claim savings for benchmarking activities in these buildings. | Current building benchmarking mandates do not cover the full building population, thus leaving a segment of buildings in California with potential for benchmarking savings but no specified mandate to benchmark energy use. Due to this and the uncertainty around whether benchmarking savings mandated by some level of government can be claimed at all, building benchmarking is excluded from the reference scenario but included in the aggressive scenario. |
| BROs | PG&E | With respect to the savings estimates for UAT, PG&E sees a large potential for double-counting with real-time feedback and—especially—with HERs. The Navigant Study states that their forecasts in the BRO sector are "the result of professional [judgment] based on program operations"18 and that the research team "adjusted penetration and applicability to avoid the double counting of savings." However, PG&E believes that it will be necessary to limit the number of BRO programs that rely on providing "usage feedback" (e.g., HER, web presentment, online audits) to optimize customer experience and facilitate evaluation. (See page 10-11 of PG&E formal comments for details) | This issue is identified and resolved in the UAT impact evaluation (2014 - 2015). The evaluation "find[s] no evidence of joint savings between the UAT and HER programs". No action taken. |
| BROs | SDG&E | to mitigate for uncertainty, SDG&E recommends providing scenarios using adjustments to the BROs programs by forecasting lower assumption values than the reference case savings forecast to estimate BRO savings and another scenario which would fall between the reference and aggressive BRO forecast savings forecast. These ranges would account for uncertainties due to future post EMV savings results that will include persistence and impacts on the rolling cycle implementation. | We have modified our HERs forecasts with lower assumption values in both the reference and aggressive case. HERs savings account for the large majority of BROs savings and the modified results should account for future uncertainties. |
| BROs | SDG&E | Retrocommissioning ("RCx") presents another concern regarding the assumptions used in the forecast. The Commission has previously acknowledged that a "grey" area between what constitutes "regular maintenance and operation" of a building and "behavioral, Retrocommissioning and operational" measures exists....The Navigant Study also focuses on HVAC for commercial RCx but the study is not clear if the savings range of 2.3% to 5.17% includes all HVAC O&M savings or the incremental amount beyond regular practice. The Navigant Study should clarify what constitutes RCx program savings in its forecast. | The savings values described are incremental HVAC O&M savings applied to each building type and are based on CEUS UEC HVAC values. |

| Topic Area | Party | Summary of Issue | Navigant Response |
|---|---|---|---|
| BROS | SDG&E | With the combination of TOU rates being adopted for all Res customers in 2020 and increased rooftop solar/battery storage adoption, SDG&E hypothesizes that HERs will not be a major source of savings in the future. | This could be addressed in future iterations of the PG study. It is expected that future impact evaluations will reflect increased adoption of DER technologies. No action taken. |
| BROS | SDG&E | Another consideration that potentially limits the expansion of HERs and behavior programs in SDG&E's territory is the current requirement that behavior programs must use a Randomized Control Treatment ("RCT") experimental design. This program design requires maintaining a comparable control group for measurement and evaluation comparison purposes. SDG&E currently has over 600,000 residential HERs/behavior program participants out of its approximately 1,000,000 customers. | Our model currently caps HERs customer penetration in part to account for the need of a Randomized Control Treatment (RCT) group. |
| BROs | SDG&E | SDG&E agrees that the evidence to-date suggests that buildings participating in benchmarking programs tend to reduce their energy use and water consumption over time (NEMA 2016, EnergyStar 2016). The Navigant savings assumption per building are reasonable but are overly aggressive at the program level. Regardless, they don't apply to utility EE programs. In California, building benchmarking for large buildings is required as part of AB 802. Benchmarking is now the baseline. In addition, in San Diego local ordinances are also in place or being developed. | Current building benchmarking mandates do not cover the full building population, thus leaving a segment of buildings in California with potential for benchmarking savings but no specified mandate to benchmark energy use. Due to this and the uncertainty around whether benchmarking savings mandated by some level of government can be claimed at all, building benchmarking is excluded from the reference scenario but included in the aggressive scenario. In the aggressive scenario, savings have been reduced based upon a review of savings sources. |
| BROs | Oracle | Most of the IOUs have significantly increased the size of their HER programs in the two years since 2017, which was the last program-year evaluated. Therefore, the assumed base penetration rates in the Study are likely not reflective of the current reality on the ground. It should also be noted that HER penetration over time is a function not only of program growth (e.g. adding customers to the program), but also of program attrition, which occurs as customers move out of their homes or otherwise opt out of the program. While intentional opt-outs are so low as to be almost negligible, attrition through customer churn is significant and can act as a substantial damper on growth once penetration rates become relatively high, as "refill" cohorts must be added to the program in order to backfill those lost to attrition. If refill cohorts are not added to the program, the overall savings from the program will attenuate as less households receive the treatment. | Attrition is nuanced dynamic not captured in the PG model. It's something that could be considered for the next PG model. We note that forecasted HERs savings in 2020 and 2021 are within reason relative the most recent HERs impact evaluation studies funded by CPUC. |

| Topic Area | Party | Summary of Issue | Navigant Response |
|---|---|---|---|
| BROs | SBUA | SBUA recommends the BROs section of the Study describe strategies specific to small business customers. Appendix C lists BROs interventions included in the PG Model, none of which are specific to small businesses | No action taken. The building segmentation is defined in the wider PG report and would require structural revision to address. |
| BROs | SCG | SoCalGas cautions against the assumptions made for BRO measures where current program delivery occurs through non-resource programs or where PAs do not currently claim savings. SoCalGas has yet to deploy the Building Operator Training in its programs, so penetration rate assumptions should be adjusted to consider the ramp up of program activities for this measure. Reference D.18-05-041, pp. 64-66. | Due to the lack of BOC programming at SCG, we have modified to model to reflect a 2020 program start date in potential savings. |
| BROs | SCG | HERS: HERS reference scenario aligns with program experience. HERS aggressive scenario is unrealistic given the diminishing pool of untreated customers over time. SoCalGas requests that Navigant provide the source used for the gas savings (noted to be 0.7% to 1.4%) in Table C-1 as it is not readily apparent. | We have modified our forecasted savings growth rate in the reference and aggressive scenarios to account for a diminished savings value in future HERs waves while maintaining our calibrated energy savings according to recent impact evaluations. Source documentation has been added to the appendix for HERs gas savings. |
| BROs | SCG | Building Benchmarking: The Navigant study should identify why there is no penetration rate for Building Benchmarking for SCG in the reference scenario. Further, a common penetration rate was applied to SoCalGas, Southern California Edison (“SCE”), and San Diego Gas & Electric (“SDG&E”) in the aggressive scenario. SoCalGas questions the appropriateness of applying this penetration rate and including forecasted savings in the aggressive scenario given the prior concerns around cost-effectiveness as indicated for the reference scenario. | Building benchmarking is a cost-effective gas measure and has been included in the aggressive scenario for SCG. |
| BROs | SCG | Interactive effects: The Navigant study should consider the growth of HER activities which may impact savings potential for UAT motivated savings. Use of an aggressive scenario for HERs, UAT, and other comparative energy use-based measures/programs have the potential to exacerbate this overlap and would not accurately represent market savings potential. | This issue is identified and resolved in the UAT impact evaluation (2014 - 2015). The evaluation "find[s] no evidence of joint savings between the UAT and HER programs". No action taken. |
| BROs | SCE | 2b, 2bi. SCE fears penetration rates for BROS and HERs may be overly optimistic; agrees with Navigant p. 70 to "consider pilot studies along with measurement and verification to provide better data to future potential studies." | We have modified our forecasted savings growth rate to account for a diminished savings value in future HERs waves while maintaining our calibrated energy savings according to recent impact evaluations. |
| BROs | SCE | 2bii. Delay universal audit tool (UAT) savings until next study cycle, because UAT savings are currently not achievable and are pending CPUC review. | UAT remains in the forecast. No policy statement expressly denies the IOUs from claiming savings. |

| Topic Area | Party | Summary of Issue | Navigant Response |
|---|---|---|---|
| BROs | SCE | 2bii. Reduce benchmarking savings by 50%. Building Benchmarking is currently a non-resource program with no claimable savings, there is uncertainty about whether IOUs will be able to claim savings from this mandated initiative. | Current building benchmarking mandates do not cover the full building population, thus leaving a segment of buildings in California with potential for benchmarking savings but no specified mandate to benchmark energy use. Due to this and the uncertainty around whether benchmarking savings mandated by some level of government can be claimed at all, building benchmarking is excluded from the reference scenario but included in the aggressive scenario. In the aggressive scenario, savings have been reduced based upon a review of savings sources. |
| BROs | PAO | The Energy Division should ensure that Alternative 2 includes only BRO measures that pass its cost-effectiveness screen. Specifically, the Energy Division should review the BRO measures and determine whether each measure has a TRC ratio of 1.25 or greater. For the purposes of estimating total market potential in Alternative 2, the BRO potential should be the sum of potential (in the Reference BRO scenario) from those measures that pass a 1.25 cost-effectiveness screen. | No action taken. BROs characterization is not as precise as rebate program measure characterization and thus a strict cost-effectiveness cutoff is not appropriate. For example, rebated equipment cost data is available from DEER, workpapers, and other CPUC and stakeholder vetted sources and are accepted, fixed values. There is not such source for BROs cost data. Instead, some judgement is required in assessing which BROs programs are effective for both programmatic savings and external benefits. |
| BROs | PAO | Modify the Reference BRO scenario to moderate the assumed expansion of Home Energy Reports. The Energy Division should reduce the expected penetration rate, by assuming that Home Energy Reports will target only the upper 50 percent of residential customers in terms of usage, rather than the 75 percent currently assumed.<br>Reduce the applicability rate of Home Energy Reports to account for master-metered manufactured homes, (see detailed discussion on page 18-19 of comments).<br>Apply a cost-effectiveness screening threshold of 1.25 to BRO measures. For Alternative 2, the Energy Division should sum the savings potential (in the Reference BRO scenario) of each BRO measure that has a TRC ratio of at least 1.25. (see detailed discussion on page 18-19 of comments).<br>Correct the treatment of Building Benchmarking or remove this measure. (see detailed discussion on page 18-19 of comments). | We have modified our forecasted savings growth rate to account for a diminished savings value in future HERs waves while maintaining our calibrated energy savings according to recent impact evaluations.<br><br>Master-metered homes are accounted for in our model and penetration is limited accordingly.<br><br>No action currently taken on cost-effectiveness nor building benchmarking. Awaiting guidance from the CPUC. |

| Topic Area | Party | Summary of Issue | Navigant Response |
|---|---|---|---|
| BROs | PAO | Remove Building benchmarking. However, if it does stay in, revise the savings assumption: Navigant used 2016 results from Chicago's benchmarking program, but 2017 data are now available. The 2017 results show sharply reduced impacts. For example, the 2016 report found that properties reduced energy consumption by 4.0 percent after two years of participation, but the 2017 report found only a 1.3 percent savings after two years. | The study's percent savings ranges from 0.4% to 1.65% and is in line with what PAO is suggesting for revision. No edits made to percent savings.<br>Current building benchmarking mandates do not cover the full building population, thus leaving a segment of buildings in California with potential for benchmarking savings but no specified mandate to benchmark energy use. Due to this and the uncertainty around whether benchmarking savings mandated by some level of government can be claimed at all, building benchmarking is excluded from the reference scenario but included in the aggressive scenario. In the aggressive scenario, savings have been reduced based upon a review of savings sources. |
| C&S | PAO | The Draft Study also appears to double-count energy savings in the residential lighting sector. The Draft Study counts energy savings in lighting that have been achieved through codes and standards, while also counting savings in lighting from the incentive programs. Table E-1 of the Draft Study lists efficiency codes and standards, including several related to lighting | The updated study shows LEDs as the baseline for residential applications removing the possibility of double counting savings. |
| CCA/REN | MCE+ Lancaster | MCE and Lancaster desire to have more detailed information on EE potential in their respective service territories to help inform future program design and development and request that the study should attempt to provide the same quality and character of information for use in designing CCA programs as it does for IOU programs. | As mentioned in the written report, disaggregation of potential to CCAs (as well as RENs and DACs) will happen at a later date after IOU goals are set. |
| CCA/REN | MCE+ Lancaster | Lancaster and MCE would like to better understand how Navigant is determining its population for IOU versus CCA allocations. Lancaster and MCE question whether a top-down approach will be able to provide valuable feedback on savings potential to CCAs because population demographics, climate zones, and EE program scope in CCAs are different from the IOUs they are closest to | As mentioned in the written report, disaggregation of potential to CCAs (as well as RENs and DACs) will happen at a later date after IOU goals are set. Documentation of our initial thinking can be found in the written workplan published in January 2019. Navigant will discuss with CPUC if a stakeholder input webinar can be hosted prior to implementing the forecast. |

| Topic Area | Party | Summary of Issue | Navigant Response |
|---|---|---|---|
| CCA/REN | BayREN | The Joint RENs urges the Commission and the Navigant team to actively seek input from the RENs and CCAs on their approach and allow them to participate in developing the criteria for determining how they would disaggregate the REN/CCA specific potentials from the IOU totals. The Goals and Potentials Study should aim to provide as much value for the REN/CCAs as for the IOUs. BayREN has similar concerns about the top-down disaggregation approach as MCE+Lancaster. | As mentioned in the written report, disaggregation of potential to CCAs (as well as RENs and DACs) will happen at a later date after IOU goals are set. Documentation of our initial thinking can be found in the written workplan published in January 2019. Navigant will discuss with CPUC if a stakeholder input webinar can be hosted prior to implementing the forecast. |
| Costs | PAO | while the Draft Study provides estimates of the savings potential and costs of resource programs, it provides no information about non-resource programs. Therefore, the Draft Study cannot provide defensible estimates of the overall C-E of effectiveness of the program administrators' portfolios. Moreover, the Draft Study's "portfolio cost-effectiveness" estimates exclude behavioral programs, which represent a large share of total savings and total spending in the forecast. The Draft Study also acknowledges that there is uncertainty about non-incentive costs. | Report will be updated to note that the results only apply to "resource portfolio cost effectiveness" and exclude non-resource program cost considerations |
| Costs | SCG | Cost assumptions should include the costs related to non-resource programs to provide a more accurate picture of portfolio cost effectiveness. Historical program costs for non-resource programs are available in the EEStats database for program years 2013-2017Q3, as well as filed program budgets for program years 2018 and 2019 in the California Energy and Data Reporting System ("CEDARS"). | It is not in scope of the potential study to account for or forecast the cost associated with non-resource programs. |
| Costs | CEDMC | CEDMC requests that the Commission take action to focus future Potential and Goals studies on the most cost-effective means for efficiency to achieve the SB 350 doubling target and contribute to other Commission energy goals, rather than simply looking at whether efficiency is cost-effective relative to marginal units today. | Thanks for your comment, it will be noted as a suggestion for future work. |
| Global Inputs | PG&E | Using the same Commission-approved census-based methodology used to update its annual low-income estimates, PG&E estimates 37.9 percent of its residential customers residing in multifamily homes with five or more units are low-income customers and 20.2 percent of its residential single-family customers are low-income customers. | Navigant has updated the analysis for PG&E with this data. It brings PG&E input data into closer alignment with the other IOUs. |

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| Global Inputs | SDG&E | The avoided costs should be updated to the new avoided costs and CO2 added values adopted by the Commission on May 16, 2019. | Navigant discussed with CPUC. Direction provided to the team was to not update avoided costs as this time. |
| Global Inputs | SCE | 2i. calibrating the model to include the most recent (2017-2018) program budget and expenditure data. | Calibration methodology/inputs were discussed at the 3/21 workshop and remains unchanged. Program budgets from 2018-2019 inform the non-incentive cost calculation in the model. |
| Low Income | PG&E | PG&E respectfully disagrees with the assumptions used in the Low-Income section of the Navigant Study. The Navigant Study does not account for the policies and methodologies required by the CPUC for the IOUs' low-income program, Energy Savings Assistance (ESA) program. (Long list of issues on page 13-17) | Low income modeling follows the scope laid out in the workplan and follows the same method proposed to CPUC in our original proposal. We recognize this isn't the perfect approach, but it was the best we could do with the extreme schedule limitations placed on the Study. Updates are not being made. |
| Low Income | SDG&E | the Navigant Study results for the low-income sector reflect the technical potential for a program that installs high efficiency equipment, replacing working and used equipment of a lower efficiency, with a very high adoption rate. Therefore, SDG&E recommends that the results from this study not be used to inform goals for the low-income sector. | The PG study forecasts market potential for LI in additional to technical potential. |
| Low Income | SCG | SoCalGas disagrees with some of the dated sources and assumptions used in the Low-Income section of the Navigant study. SoCalGas notes that a more recent version of the Low Income Needs Assessment (LINA) study is available, and that the Impact Evaluation of the ESA Program for Program Years 2015-2017 final report ("ESA Program Impact Evaluation") was recently been released. Conclusions from the ESA Program Impact Evaluation indicate that ex ante savings assumptions were higher than achieved savings, with some measures leading to an increase in consumption | Low income modeling follows the scope laid out in the workplan and follows the same method and data sources proposed to CPUC in our original proposal. Navigant used the 2013 LINA study combined with the CLASS database to obtain ownership and efficiency levels of equipment in 2013 (the year the model starts is calibration). The 2016 LINA was reviewed but it did not contain the type of data useful to comprehensively model potential. The draft ESA evaluation referenced in this comment was used to adjust savings input estimates for the LI sector that results in significant reductions to LI potential. |
| Low Income | SCG | The Navigant study does not account for decision factors which differ for customers within the energy savings assistance program(s) versus customers participating in conventional EE programs | Low income modeling follows the scope laid out in the workplan and follows the same method proposed to CPUC in our original proposal. We recognize this isn't the perfect approach, but it was the best we could do with the extreme schedule limitations placed on the Study. Updates are not being made. |

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| Low Income | SCG | Results viewer and report clarification: Low-income savings potential presented in the web-based Results Explorer in the "Market potential" and "Savings Scenarios" tabs differ from the tables presented in Appendix H for the detailed scenario results. This difference is due to BROs measure potential forecasted for the low-income sector. To reduce confusion in identifying energy savings potential from the low-income sector attributed to low-income programs, this difference should be identified in the Results Explorer. | BROs will be clarified to be all Residential sector savings that count towards resource programs. Low income savings will only reflect savings from the ESA program. |
| Low Income | SCE | 2d. Model is misaligned with Energy Savings Assistance (ESA) program rules, policies, and program changes ongoing in the low-income proceeding. Recommendations: 1) Wait for ESA program to complete post 2021 program planning to avoid prematurely estimating ESA savings; 2) Strive to keep the savings aligned with ESA program plans; 3) Update ESA savings estimates based on ESA program plans in SCE's upcoming ESA/CARE application | Low income modeling follows the scope laid out in the workplan and follows the same method proposed to CPUC in our original proposal. We recognize this isn't the perfect approach, but it was the best we could do with the extreme schedule limitations placed on the Study. Updates to methodology are not being made. Updates to inputs were made to account for recent ESA impact evaluation. |
| Low Income | PAO | The Draft Study inappropriately uses a market-adoption model to forecast the diffusion of efficient technologies in the low-income residential sector. This model is not applicable to the Energy Savings Assistance program (ESA), where customers are not making a purchasing decision. | Low income modeling follows the scope laid out in the workplan and follows the same method proposed to CPUC in our original proposal. We recognize this isn't the perfect approach, but it was the best we could do with the extreme schedule limitations placed on the Study. Updates are not being made. |
| Low Income | NRDC | Low-Income Market Potential Estimates Are Meaningless; Low-Income Technical Potential Should Inform Low-Income Sector Goals Through a Low-Income Specific Proceeding | Market potential results themselves are not "meaningless". They have value. The California Energy Commission cannot use technical potential to inform IEPR or other procurement planning activities. A value representing market potential for LI must be produced in time for the next IEPR cycle. NRDC has not proposed how to convert technical potential to annual achievable potential value for LI, therefore we continue to produce a market potential value. |
| Modeling | SDG&E | Include both the 2017 and 2018 claimed EE results for purposes of calibration. Both years have integrated final Commission dispositions which were not specifically accounted for in the Navigant Study. Calibrate the model by eliminating the 0.75 NTG for below code savings. | Calibration methodology/inputs were discussed at the 3/21 workshop. We are removing the 75% multiplier for the below code NTG per guidance from CPUC. |

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| Modeling | SCE | 2a. Currently, Administrative and Marketing costs are allocated to the measure level based on energy savings proportions. This cost allocation method paints all alike measures with the same cost allocation. In practice, similar measures can be found in different programs containing drastically different administrative and Marketing costs. Appropriately allocating administrative and marketing costs at the measure-level would provide a higher degree of accuracy. | Thanks for your comment, it will be noted as a suggestion for future work. |
| Modeling | PAO | The Draft Study estimates potential for each measure at the geographical level of a utility service territory. Unfortunately, it does not account for differences in climate within service territories. This results in distorted estimates of the market potential of climate-sensitive measures. The Public Advocates Office recognizes that it may not be feasible to make changes to the model to account for climate-sensitive measures geographically before approval of goals for 2020. However, at a minimum, the Commission should direct the Energy Division to update the model to account for climate-sensitive measures for the subsequent potential and goals cycle | Thanks for your comment, it will be noted as a suggestion for future work. |
| Modeling | NRDC | Economic potential discrepancy: Approximately 1,400 (~33%) of the total gas and electric measures considered by Navigant have an economic potential that is a fraction (instead of being equal to technical potential if the measure is cost-effective or being zero if the measure isn't cost-effective) of the technical potential in year 2020. Some measures even have negative economic potential savings even though they have positive technical potential savings. | Economic potential is calculated at a more granular level than what is shown in the results databases (new construction vs. existing buildings). These instances are cases where the measure is cost effective for NC but not existing buildings. In some cases one replacement type can have negative peak demand saving while the other has positive. These are not errors but deliberate calculations.  Report explanation of methodology has been updated to reflect this. |
| Modeling | NRDC | Some measures have economic potential estimates that are much greater (by a factor of 20) of the technical potential estimates. | In the draft report this occurred in 2 line items out of 6700+ lines specifically isolated to two minor low income building envelope measures saving natural gas. Minor updates made to the algorithms for technical and economic potential corrected this issue.  Given this impacted such a small subset of measures with so little gas savings, the impact of this correction on overall results is not noticeable. |

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| Modeling | NRDC | The potential study should provide informed guidance on how utility programs can best target and acquire incremental cost-effective energy savings. This potential study does not accomplish this. The Navigant study applies broad averages and at-best reconstructs existing program portfolios... Given the design of the existing study, NRDC recommends that the study results shouldn't be called "Market Potential," but rather "Existing Programmatic Achievable Potential." | Comment doesn't impact results of the model but is rather an opinion on how to interpret the results. Our scope was to forecast a market potential that is calibrated to recent program activity and adheres to current policies. |
| Modeling | NRDC | NRDC understands that modeling measures at the climate zone level may be too onerous, we thus (again) recommend that Navigant break-up each aggregated IOU level climate sensitive measure into two measures: one representing the coastal climate zones and one representing inland climate zones. These two sets of measures should then be modeled separately as a part of the technical, economic, and market potential analysis. | Thanks for your comment, it will be noted as a suggestion for future work. |
| Res/Com | PG&E | Remove residential lighting measures. Starting January 1, 2020, the residential lighting measures included as part of the savings potential will be governed by Title 20 code and therefore should not be included in the market potential. | Study has been updated to assume LEDs without integrated controls are the baseline in all residential lamp and pin-based fixture applications. Linear lamps (a very small amount of savings potential) fort the residential sector do not assume LEDs are baseline in our model. |
| Res/Com | PG&E | PG&E submitted three non-residential lighting workpaper revisions that proposed updates to the NR baseline to include linear LED lamps as part of the LED technology baseline. The Energy Division approved these revisions via dispositions on May 13, 2019 with the updated baseline methodology that should enable additional cost-effective savings potential for LED Highbay/Lowbay Lighting and LED Linear Ambient Lighting. Preliminary cost effectiveness analysis of LED Parking Garage Lighting does not yield cost effective measures once the standard practice baseline fully transitions to 100% LED technology on January 1, 2020. PG&E recommends that Navigant discuss these methodology changes and review the approved workpapers on www.deeresources.net. | These workpapers were approved 13 days after the draft report was issued limiting our ability to update the analysis. The PG study assumed LED fixtures are 100% baseline for commercial lighting. Assuming linear LED lamps as part of the LED technology baseline would decrease the baseline thus allowing additional LED savings to be claimed by the IOUs. Given the short timeline of the study, we are unable to incorporate this update. The implication is that the resulting commercial lighting forecast would be conservative and additional savings may be claimed by IOUs. Goals are a floor not a ceiling and utilities are able to claim savings for measure that are not in the PG study so long as they are approved by the CPUC. |

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| Res/Com | PG&E | PG&E respectfully disagrees with several assumptions used in the Whole Building section of the Navigant Study, particularly for Commercial and Residential Zero Net Energy (ZNE) measures. Savings potential attributed to new construction should be removed from the Whole Building section as Residential and Non-Residential ZNE measures should not have passed C-E screening thresholds of 1.0 or greater—Residential and Non-Residential New Construction programs have not historically achieved TRCs greater than 1.0. | 2019 T24 codes do not push energy efficiency to the maximum, nor do they require ZNE. Comparing 2019 T24 compliant building energy consumption to modeled ZNE building prototypes shows savings is still possible above and beyond 2019 T24. Comment does not propose alternate data or specific edits to make. |
| Res/Com | PG&E | Remove: Commercial \| LED Display Case Lighting | There is no formal ISP study or policy on baseline for this. Furthermore, our list of measures within the ComRef end use doesn't reflect the full measure lists offered by IOUs, there are other sources of savings in this sector/end use. In reviewing 2019 and 2018 data from IOUs total ComRef savings is about the same as the PG model forecasts in 2020. Therefore 2020 ComRef forecasted savings are consistent with recent programs. |
| Res/Com | PG&E | Remove: Commercial \| EC Motors on Walk-Ins | The team made edits to this measure based on the cited code. |
| Res/Com | PG&E | Remove: Residential \| Recycle Appliances | We continue to include appliance recycling in the PG study. Past failure of implementers is not an indication of future potential. The PG study uses market data and stock turnover algorithms to come to the conclusion that there are still secondary appliances in the market that could be targeted for recycling. |
| Res/Com | PG&E | Remove: Residential \| CFL Fixture | The model was updated to set LEDs as the baseline technology effectively removing this measure. |
| Res/Com | PG&E | Remove: Commercial \| Bi-Level Stairway Lighting | The model was updated to assume this measure is baseline starting in 2016. |
| Res/Com | PG&E | Review data and NTG assumptions for: Residential \| Most Eff. Heat Pump Clothes Dryer. "There were 143 heat pump dryers sold through ENERGY STAR Retail Products Platform (ESRPP) program in 2018 in PG&E territory. Therefore PG&E believes the market sizing is not appropriate." "NTG should be adjusted to 0.19 per PGECOAPP128." | Low sales from existing programs is not indicative of potential for savings. Navigant reviewed the cited workpaper and could not find any mention of 0.19 as a NTG value. No edits are being made. |
| Res/Com | PG&E | Review baseline and NTG assumptions for: Residential \| Heat Pump Water Heater | Upon review, our measure description was old and has been corrected. The baseline is correct and data is sourced from most recent DEER. No data changes were made. |

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| Res/Com | PG&E | Review baseline and NTG assumptions for: Commercial \| Demand Controlled Ventilation (DCV) Exhaust Hood. | We reviewed inputs and they match the sources cited by the comment. |
| Res/Com | SDG&E | For future Potential Studies, SDG&E recommends that Commission Staff prioritize updating the measure costs in a timely manner so that it can be incorporated in the Potential Studies. | Thanks for your comment, it will be noted as a suggestion for future work. |
| Res/Com | SDG&E | SDG&E does not agree with the Navigant Study assumption that significant nonresidential whole building savings are achievable beyond the 2019 Title 24 ("T24") building energy codes except for currently exempt building types. | 2019 T24 codes do not push EE to the max, nor do they require ZNE. Comparing 2019 T24 compliant building energy consumption to modeled ZNE building prototypes shows savings is still possible above and beyond 2019 T24. |
| Res/Com | Google (Nest) | RE: Smart Thermostats. The current cost indicated in MICS is $219.17, which is higher than is seen in the market as well as the draft revised smart thermostat workpaper, which is currently being revised. For example, the Nest Thermostat E retails at $169, well below the measure cost indicated in MICS. The correct measure cost is $142.46, as noted in the draft revised smart thermostat workpaper. Though the measure input cost source shown in MICS notes, "Use draft WP as proxy Work Paper SW13XX### Residential Smart Thermostat," this does not utilize the most recent cost numbers. Additionally, the labor cost noted in MICS is too high, noting a cost of $56.48. Labor cost should similarly be revised to reflect the updated draft workpaper value of $26.26. | Navigant has reviewed data provided and updated cost input data accordingly. |
| Res/Com | Google (Nest) | RE: Smart Thermostats. The Navigant study should use cooling baselines specific to each climate zone, rather than averaging cooling loads across utility service territories | Navigant has reviewed and updated cooling baselines to match those found in CBECC-Res. |
| Res/Com | Google (Nest) | In analyzing customer smart thermostat setpoints as part of the process of updating the current smart thermostat workpaper, Google Nest discovered that Database of Energy Efficiency Resources ("DEER") baseline cooling load estimates appear inaccurate. This baseline inaccuracy has broad implications for a range of measures – including, but not limited to smart thermostats – and therefore requires further study. Google Nest believes that research is needed to better characterize cooling loads by housing type because current values appear questionable, yet play a central role in projected savings for many efficiency upgrades. | Updates were made for thermostats but this study is not making more broad adjustments to DEER-sourced data. |

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| Res/Com | SBUA | Therefore, the Study should further examine how a whole building retrofit would or would not meet the EE needs of small businesses and suggest how the concern over disruption of business operations could best be addressed, whether that be through measure-specific rebate program designed specifically for small businesses or through other strategies. | The scope of the study does not call out the "small business" subsector specifically. Rather potential savings is report for the commercial sector as a whole disaggregated to building types. |
| Res/Com | SCE | 2ii. Recommends the lighting end uses account for the impending DOE standard changes, specifically impacts to general service lamps (GSL). | Study has been updated to assume LEDs without integrated controls are the baseline in all residential lamp and pin-based fixture applications. Linear lamps (a very small amount of savings potential) do not assume LEDs are baseline in our model. |
| Res/Com | SCE | 2iii. Remove residential appliance recycling and advanced power strips be removed from measure list. | Conservative adjustments have already been made to power strips to reduce savings 50%. We continue to include appliance recycling in the PG study. Past failure of implementers is not an indication of future potential. The PG study uses market data and stock turnover algorithms to come to the conclusion that there are still secondary appliances in the market that could be targeted for recycling. |
| Res/Com | SCE | 2c. Incorporate recommended policy changes (2ii, 2iii) into Whole Building modeling, (lighting, advanced power strip, appliance recycling changes). | Res whole building savings were reduced to account for the shift to LED baseline. |
| Res/Com | PAO | Although compact fluorescent lamps (CFLs) can meet current efficiency standards, consumers are rapidly shifting to light-emitting diode (LED) lamps. Therefore, it is appropriate to treat LEDs as the baseline for all residential lighting applications. | Study has been updated to assume LEDs without integrated controls are the baseline in all residential lamp and pin-based fixture applications. Linear lamps (a very small amount of savings potential) do not assume LEDs are baseline in our model. |
| Res/Com | PAO | Contrary to California and federal requirements, the Draft Study includes CFL measures. Inclusion of CFL measures is inappropriate because utilities should not continue to provide incentives to customers, at the ratepayers' expense, to adopt a technology that is mandated by efficiency standards, inferior to a readily available alternative, and less cost-effective than the alternative LEDs. The Commission considered this issue in D.18-05-041 and ordered EE program administrators to discontinue all incentive payments for CFLs by December 31, 2018. | Study has been updated to assume LEDs without integrated controls are the baseline in all residential lamp and pin based fixture applications. Linear lamps (a very small amount of savings potential) do not assume LEDs are baseline in our model. |

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| Res/Com | PAO | remove appliance recycling | We continue to include appliance recycling in the PG study. Past failure of implementers is not an indication of future potential. The PG study uses market data and stock turnover algorithms to come to the conclusion that there are still secondary appliances in the market that could be targeted for recycling. |
| Res/Com | NRDC | The study authors should ensure that incremental costs applied for all measures are consistent in meaning. As it stands, the incremental costs for a subset of the measures represents the incremental cost of solely efficiency increase while others represent the full difference in measure price. This difference in incremental cost meaning results in the potential model incorrectly favoring some measures over the other. Moreover, the study authors should critically examine which incremental cost – cost of efficiency increase or total incremental cost – should drive measure adoption. | Cost data is sourced from DEER, workpapers, and CPUC/Itron measure cost study from 2012. In many cases DEER incorporates data from the Itron study. Its not in our scope to scrutinize the validity of incremental cost data but rather to accept CPUC produced data as approved for use in planning/forecasting efforts. |
| Res/Com, AIMS | SCE | 2iv. Revaluate measure level savings of mining and low-income to make P/E ratios more consistent with actual program savings. | Navigant updated data in response to this comment using EEstats program data from 13-16 to calculate a revised P/E ratio. |
| Res/Com, AIMS | SCE | 2a. Use 2019/2020 DEER and IOU workpaper cost data, not the cited "California Measure Cost Study (2012)" | For Res/Com measures the majority of data for Cost in DEER comes from the Itron cost study (2012) unless they have been updated by workpapers. For AIMS, we are calculating the $/kWh consumed. Workpapers and DEER are based on a $/widget. There is insufficient data to convert this without some gross assumptions. |